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# Ultramafic Rocks of the Island Lake Area

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# TABLE OF CONTENTS


| | Page |
|---|---|
| **INTRODUCTION** | 1 |
| Previous work | 1 |
| Acknowledgements | 1 |
| **GENERAL GEOLOGY** | 1 |
| **ULTRAMAFIC ROCKS** | 1 |
| Ultramafic rocks in the Island Lake area | 3 |
| **SELECTED ULTRAMAFIC OCCURRENCES IN THE ISLAND LAKE AREA** | 4 |
| Linklater Island area | 4 |
| Occurrence #2 | 4 |
| Occurrence #3 | 4 |
| Occurrence #4 | 4 |
| Ultramafic rocks west of Linklater Island | 4 |
| Fleet Point | 4 |
| Ultramafic rocks south of Linklater Island | 4 |
| Stevenson Island Area | 4 |
| "Trinity Shoals" (Occurrence #1) | 4 |
| Jubilee Island (Occurrence #2) | 5 |
| Sandy Bar Narrows area | 5 |
| Sagawitchewan Bay area | 6 |
| Spinifex textured rocks in Sagawitchewan Bay | 6 |
| Henderson Island | 7 |
| **GEOCHEMISTRY OF ULTRAMAFIC AND RELATED ROCKS** | 7 |
| Geochemistry | 7 |
| **GENETIC MODELS** | 17 |
| Discussion | 17 |
| **MINERAL POTENTIAL** | 17 |
| Nickel mineralization | 17 |
| Platinum group mineralization | 17 |
| Gold mineralization | 17 |
| **REFERENCES** | 19 |
| **APPENDIX I:** Important geological features of ultramafic rocks in the Island Lake area | 22 |
| **APPENDIX II:** Chemical composition of ultramafic rocks - Island Lake; | |
| (a) Raw data | 25 |
| (b) Normalized data | 29 |

## TABLES


| | | Page |
|---|---|---|
| TABLE 1: | Table of formations | 2 |
| TABLE 2: | Representative analyses of ultramafic rocks from the Island Lake area and Munro Township | 9 |
| TABLE 3: | Trace element contents of olivine cumulates from the Island Lake area | 10 |
| TABLE 4: | CIPW-cation equivalent norms of representative ultramafic rocks | 11 |


## FIGURES


| | | Page |
|---|---|---|
| FIGURE 1: | Major geological subdivisions of Manitoba and location of the Island Lake greenstone belt | Facing 1 |
| FIGURE 2: | Diagrammatic section of an ultramafic flow unit | 3 |
| FIGURE 3: | Generalized geology, and location of ultramafic rocks in the Island Lake area | in pocket |
| FIGURE 4: | Location of ultramafic rocks in the Linklater Island area | in pocket |
| FIGURE 5: | Geology and location of ultramafic rocks in the Stevenson Island area | in pocket |
| FIGURE 6: | Geology of the Sandy Bar Narrows and Loonfoot Island area | in pocket |
| FIGURE 7: | Geological sketch-map of the Sandy Bar Narrows area | 5 |
| FIGURE 8: | Location of ultramafic rocks in the Sagawitchewan Bay area | in pocket |
| FIGURE 9: | Geological sketch map of ultramafic occurrence #6 (Sagawitchewan Bay area) | 6 |
| FIGURE 10: | Geological sketch map of the Henderson Island area | in pocket |
| FIGURE 11: | Outline of areas of lithogeochemical surveys | 7 |
| FIGURE 12: | $Al_2O_3$ vs (FeO + $Fe_2O_3$ + $TiO_2$) vs MgO Diagrams; (a) Linklater Island; (b) Sandy Bar Narrows; (c) Sagawitchewan Bay | 8 |
| FIGURE 13: | ($Na_2O$ + $K_2O$) vs FeO vs MgO diagrams; (a) Linklater Island; (b) Sandy Bar Narrows; (c) Sagawitchewan Bay | 8 |
| FIGURE 14: | CaO vs MgO vs $Al_2O_3$ diagrams; (a) Linklater Island; (b) Sandy Bar Narrows; (c) Sagawitchewan Bay | 8 |
| FIGURE 15: | $Al_2O_3$ vs FeO/(FeO + MgO) diagram | 11 |
| FIGURE 16: | $TiO_2$ vs $Cr_2O_3$ diagram | 12 |
| FIGURE 17: | (a) MgO vs Ni; (b) MgO vs Cr diagrams | 12 |

## PLATES


| | | Page |
|---|---|---|
| PLATE 1A: | Photomicrograph of typical olivine cumulate. | 13 |
| PLATE 1B: | Photomicrograph of serpentinized olivine cumulate. | 13 |
| PLATE 1C: | Photomicrograph of antigorite cumulate. | 13 |
| PLATE 1D: | Photomicrograph of pyroxene cumulate. | 13 |
| PLATE 2A: | Photomicrograph of olivine cumulate. | 14 |
| PLATE 2B: | Photomicrograph of olivine spinifex. | 14 |
| PLATE 2C: | Photomicrograph of olivine cumulate. | 14 |
| PLATE 2D: | Photomicrograph of olivine cumulate. | 14 |
| PLATE 3A: | Photomicrograph of antigorite pseudomorphs after olivine. | 15 |
| PLATE 3B: | Photomicrograph of amphibolitized clinopyroxene cumulate. | 15 |
| PLATE 3C: | Photomicrograph of "gabbro". | 15 |
| PLATE 4A: | Flow top breccia, ultramafic occurrence #6 (Sagawitchewan Bay). | 16 |
| PLATE 4B: | Photomicrograph of pyroxene spinifex. | 16 |
| PLATE 4C: | Olivine spinifex; Unit I. | 16 |
| PLATE 4D: | Olivine spinifex; Unit II. | 16 |

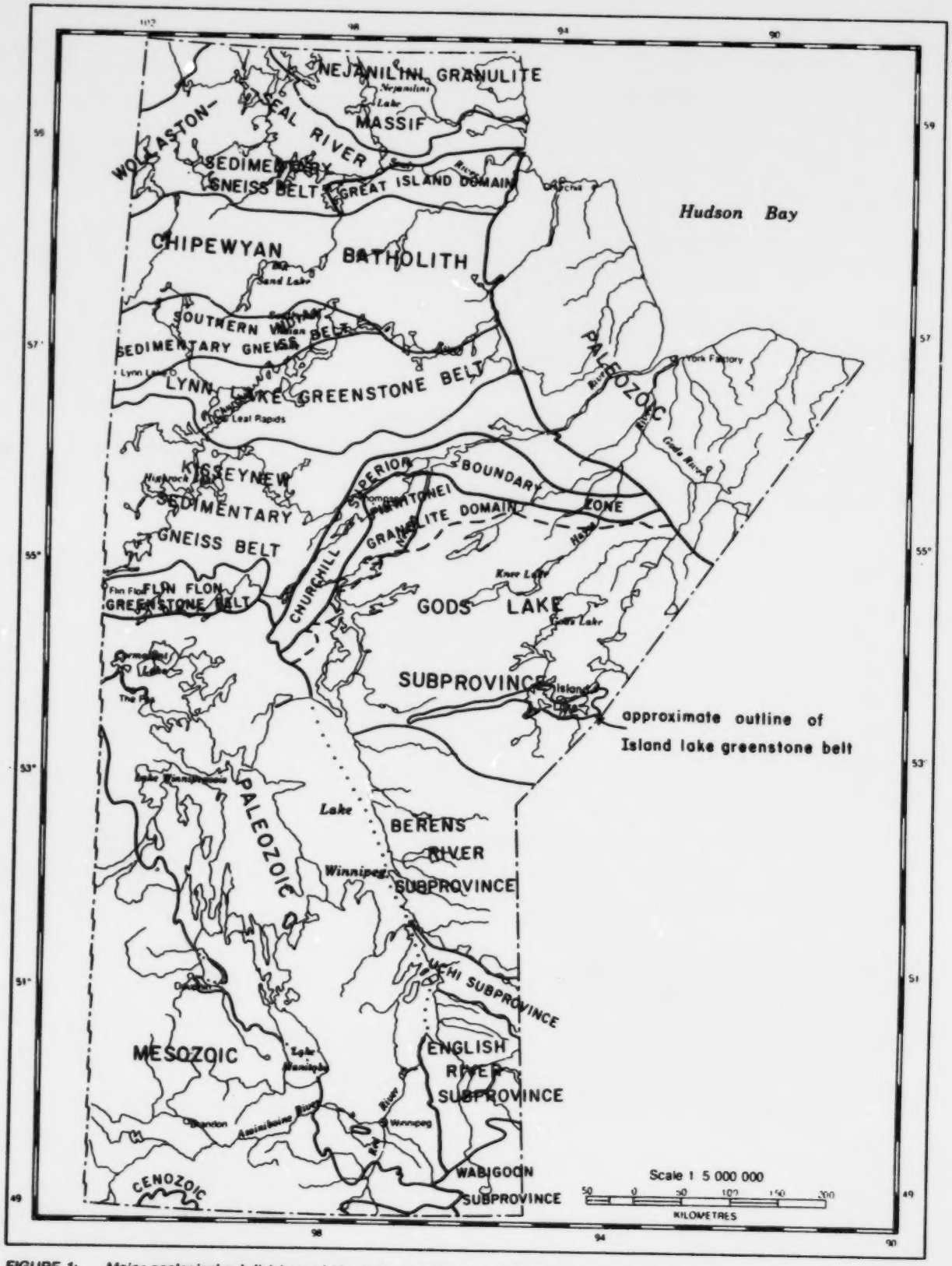


*FIGURE 1: Major geological subdivisions of Manitoba and location of the Island Lake greenstone belt.*

## INTRODUCTION

This report presents the results of a study of ultramafic rocks in the Island Lake area (northeastern Manitoba). Funding for this project was provided by the Federal-Provincial cost-shared Northlands Agreement during 1980-81 and by the Province of Manitoba from 1981 until present.

Island Lake is located approximately 430 km northeast of Winnipeg. The area included in this study is bounded by latitudes 53°45′ and 54°00′ and longitudes 94°00′ and 95°00′ west. It is a part of map sheet NTS 53E (Fig. 1). Island Lake is accessible by scheduled aircraft service from both Winnipeg and Thompson. Ground access is restricted to winter roads. A canoe route of historic interest extends from Norway House via the Nelson, Gunisao and McLaughlin Rivers to Ponask Lake, Stevenson Lake and finally into Collins Bay of western Island Lake.

### PREVIOUS WORK

Geological investigations of the Island Lake greenstone belt were initiated by Wright (1928) who divided the supracrustal rocks into older, mainly volcanic rocks of the Hayes River Group, and a stratigraphically overlying, mainly sedimentary rock unit which he designated the Island Lake "Series". Gold mineralization in quartz veins and sheared felsic volcanic rocks discovered during the early 1930s encouraged prospecting activity and geological mapping. However, few records of this prospecting work are contained in the assessment files of the Mineral Resources Division. McMurchy (1944) reviewed the geology and mineralization of the area. Godard (1963a, 1963b) produced a geological map and report of the entire Island Lake area. Quinn (1960), Ermanovics et al. (1975), Herd and Ermanovics (1976) and Fyson et al. (1978) published the results of regional mapping programs. Quinn and Meinert (1959) discussed the geology and composition of the Island Lake "Series". Ames (1975) described several ultramafic rock occurrences. Theyer (1978, 1980a, 1980b, 1981 and 1982) described various aspects of the mineral deposit geology as well as the stratigraphic position of ultramafic rocks.

Ultramafic rocks in the Island Lake area were geologically mapped and sampled after a thorough examination of textural and compositional characteristics. Specific features such as the occurrence of rubble breccia, pillows, spinifex textures, grain size sorting and layering were used to infer the mode of emplacement and stratigraphic orientation of the rock in outcrop.

Ultramafic rocks of the area were classified into three major groups based on stratigraphic, chemical and petrological data. The lack of continuous outcrop and the poorly defined stratigraphy and tectonism of the Island Lake greenstone belt hampered this project. This study concentrated initially on ultramafic rocks and associated mineralization. However, all mineral deposits were subsequently studied, following the identification of a geological relationship between stratabound gold mineralization and the rock unit hosting ultramafic rocks of possibly extrusive nature (Theyer, 1980a). This report will describe the ultramafic rocks and their associated mineralization: the mineral deposit studies will be presented subsequently.

In 1981 the Geological Services Branch of the Department of Energy and Mines initiated a mapping program in the Island Lake area. A geological map of the Cochrane Bay and Sinclair Islands areas was published by Neale and Weber (1981). Weber et al. (1982) published a preliminary geological map of the northern and western part of Island Lake and a proposal for a revised stratigraphy (Table 1). Mapping of western Island Lake has been completed recently (Gilbert and Weber, 1983).

### ACKNOWLEDGEMENTS

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## GENERAL GEOLOGY

Ultramafic rocks occur within the Island Lake greenstone belt. This belt is part of the Gods Lake Subprovince of the Superior Geological Province. It extends west from the Ontario-Manitoba boundary to northeast of Lake Winnipeg (Fig. 1).

The oldest supracrustal rocks in the Island Lake area are mafic, intermediate and felsic volcanic rocks and derived epiclastic and chemical sedimentary rocks of Archean age (Wright, 1928: "Hayes River Group"). The intrusion of tonalitic batholiths into the Hayes River Group produced, according to Weber et al. (1982), local areas of deformation, uplift and subsequent erosion which resulted in the deposition of Hayes River Group epiclastic rocks. Theyer (1978, 1980a) proposed that ultramafic intrusive and extrusive rocks were emplaced within sedimentary rocks at the base of the Island Lake "Group". Weber et al. (1982) concurred with the concept of a post-Hayes River Group ultramafic intrusive and extrusive event; however, they suggested that these rocks were emplaced as part of a third group of mafic to felsic volcanic rocks and tonalite batholiths that is intercalated between the Hayes River Group and the Island Lake "Group" of rocks (Table 1). Clastic sedimentary rocks of the Island Lake "Group" unconformably overlie both the Hayes River Group and the intermediate group of rocks. The Island Lake "Group" includes sedimentary rocks of fluvial, littoral and turbiditic origin which accumulated in a gradually subsiding sedimentary basin (Weber et al., 1982). Rocks of the Island Lake "Group" are intruded by mafic dykes of Archean age and by Molson dykes of Proterozoic age.

## ULTRAMAFIC ROCKS

"Ultramafic rocks" have been defined by Williams et al. (1954) as "rocks containing more than 70 per cent mafic minerals". Unaltered ultramafic rocks consist mainly of olivine, clinopyroxene, orthopyroxene, amphibole and biotite. Serpentines are the most common mineral constituent in the ultramafic rocks of the Island Lake area; talc is rare but present.

Rocks of ultramafic composition may be emplaced as extrusive or intrusive rocks. The differentiation of their mode of emplacement is often encumbered by the tendency of ultramafic rocks to concentrate tectonic strain that subsequently obliterates their primary rock fabrics, textures, and associations.

Ultramafic intrusive rocks may be distinguished from those of extrusive nature by crystal habits, especially those of olivine and pyroxene. Skeletal crystals of these minerals produce crystalline quench textures (Viljoen and Viljoen, 1969), or spinifex textures (Nesbitt, 1971) that have been considered to indicate rapid in situ cooling of a phenocryst-poor supercooled magma. Spinifex textures were regarded as indicators of a volcanic extrusive regime (Viljoen and Viljoen, 1969;

**TABLE 1**

**Table of Formations (after Weber et al., 1982)**

| | | | |
|---|---|---|---|
| PROTEROZOIC | | 16 | Molson dykes |
| ARCHEAN | Post-Tectonic Plutonic Rocks | 15 | Granites (intruding Chapin Bay tonalite) |
| | | 14 | Plagioclase + quartz phyric dykes |
| | | 13 | Mafic dykes, metamorphosed |
| | Late Plutonic Rocks | 12 | Tonalite quartz diorite, felsic to intermediate dykes |
| | | | INTRUSIVE CONTACT |
| | Late Metasedimentary Rocks "ISLAND LAKE GROUP" | 11 | Turbidity current deposits: wacke, siltstone, argillite |
| | | 10 | Regolith: wacke, breccia (on unit 6); fluvial deposits: tonalite-and volcanic-derived conglomerate, cross-bedded wacke, siltstone, argillite |
| | | | UNCONFORMITY |
| | Early Plutonic Rocks | 9 | Felsic metavolcanic rocks, related metasedimentary rocks, subvolcanic porphyries |
| | | 8 | Mafic intrusive rocks |
| | | 7 | Ultramafic intrusive, subvolcanic or flow rocks |
| | | 6 | Tonalite batholiths (Bella Lake, Waasagomach, Chapin Bay, Bunny Island), related rocks |
| | | | INTRUSIVE CONTACT |
| | Early Supracrustal Rocks HAYES RIVER GROUP | 5 | Conglomerate, mainly sedimentary-derived |
| | | 4 | Wacke, siltstone, argillite, conglomerate, chert, iron formation, carbonate |
| | | 3 | Wacke, conglomerate, derived from felsic to intermediate pyroclastic deposits, interlayered with siltstone and argillite |
| | | 2 | Felsic to intermediate metavolcanic rocks: flows, pyroclastics, and related subvolcanic porphyries |
| | | 1 | Mafic to intermediate metavolcanic rocks: flows, tuffs, breccias and related subvolcanic gabbro sills |

Nesbitt, 1971). However, Donaldson (1974 and 1976) has shown that skeletal olivine may also grow in olivine-rich supersaturated melts at slow cooling rates typical of intrusive rocks. He argued that crystal habits and crystal sizes cannot be used as a reliable index of cooling rates since supersaturation of a melt, resulting in the growth of skeletal crystals, may also be achieved in magnesia-rich melts by the following two mechanisms: (a) adiabatic expansion of the magma, or (b) changes in the magmatic water content. Arndt and Brooks (1980) also argued that knowledge of the chemical composition of the melt is of crucial importance in understanding the genesis of spinifex textures and their purported significance as indicators of rapid cooling, i.e., of deposition as volcanic rocks. However, the compositional inhomogeneities intrinsic to a stratified volcanic flow, such as the presence of cumulate zones, make careful sampling across the thickness of a volcanic flow and averaging of the analytical results necessary. The average chemical composition of such a sample series can be expected to resemble the true composition of the original melt.

Descriptions of spinifex textured ultramafic rocks are abundant from Archean terrains but are relatively rare from rocks of Proterozoic or younger age. Ultramafic volcanic flows with spinifex textured upper sections underlain by cumulates are common (see Pyke et al., 1973; Arndt et al., 1979). In their classic description of spinifex textured ultramafic flows of Munro township, Pyke et al. (1973) distinguished several regularly occurring zones (see Fig. 2) namely:

Zone $A_1$: chilled flow top containing skeletal olivines in a glassy matrix with polyhedral fractures

Zone $A_2$: spinifex zone, with sheaves of olivine that exhibit a progressive increase in size downwards

Zone $B_1$: uppermost of the cumulate zones, varying between 1 cm and 30 cm thickness, containing skeletal olivine cumulate

Zone $B_2$: comprising peridotite in gradational contact with zone $B_1$

Zone $B_3$: knobby weathering layer of olivine and minor clinopyroxene in a glassy matrix

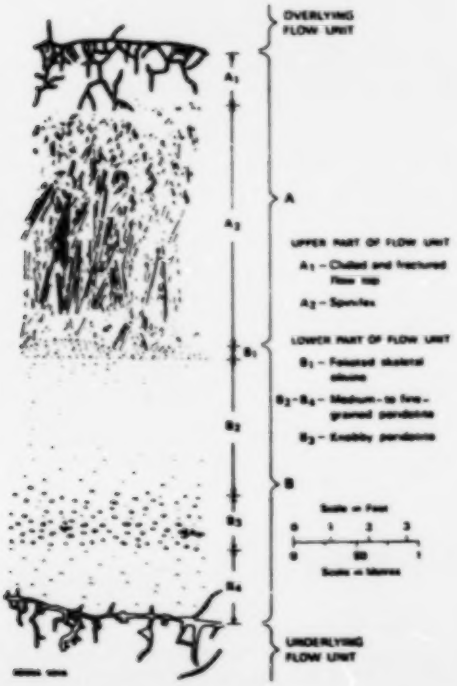


*FIGURE 2: Diagrammatic section of an ultramafic flow unit (from Pyke et al., 1973).*

Zone $B_4$: basal peridotite consisting of olivine cumulate, with a generally chilled basal margin

## ULTRAMAFIC ROCKS IN THE ISLAND LAKE AREA

The ultramafic rocks of the Island Lake area (Fig. 3) are separated into three units based on their stratigraphic setting and petrographic affinities.

Unit I ultramafic rocks occur as discrete stratabound lenses associated with epiclastic sedimentary rocks, mafic volcanic flows and gabbro. Epiclastic sedimentary rocks comprise black slate, gritty slate, minor arkose and chert. Stratigraphically they are considered to lie between the Hayes River Group and the overlying Island Lake sediments (Theyer, 1980a). Weber et al. (1982) however interpret these rocks (their Unit 4) to be the upper part of the Hayes River Group (Table 1).

Unit II ultramafic rocks (Fig. 3) are discrete lenses composed of olivine orthocumulate, talc-sericite schist and serpentinized peridotite. The original relationship of the ultramafic rocks to their country rocks is unclear since they occur either on isolated islands composed entirely of ultramafic rocks (Trinity Shoals, Occurrence #1, Fig. 5; south of Linklater Island, Occurrence #13, Fig. 4) or exhibit faulted and sheared contacts with adjoining rocks (Fleet Point North and South, Occurrences # 11 and #12, Fig. 4; Henderson Island, Fig. 10).

Two peridotite occurrences on Jubilee Island, (designated as Unit III ultramafic rocks) are interpreted as the stratigraphically lower part of a mafic to ultramafic sill.

In addition to volcanic glass the original mineral phases in the ultramafic rocks comprised: olivine, clinopyroxene, feldspar, chromite, biotite and sphene. Serpentinization and related (lower greenschist facies) metamorphism destroyed virtually all the primary phases (Plate 1A). Accordingly most of the "olivine" mentioned in this text constitutes "serpentine pseudomorphs after olivine".

The most mafic of the ultramafic rocks is an olivine orthocumulate containing minor quantities of euhedral to subhedral chromite. Postcumulate clinopyroxene exhibits gradational increases in size and abundance from interstitial (less than 1 mm) crystals to large (up to 1 cm) ophitic crystals (Plate 1B). The resultant rock is an olivine-clinopyroxene (chromite) cumulate (see Occurrence #11, Fig. 6). Increasing amounts of feldspar included in these rocks results in a feldspar-clinopyroxene cumulate ("gabbro"), the most felsic type of Unit I ultramafic rocks.

Olivine is serpentinized to antigorite and minor quantities of chrysotile (Plate 1C). Antigorite is sporadically metamorphosed to tremolite e.g. Occurrences #2 and #3, in the Linklater Island area (Fig. 4). Clinopyroxene is metamorphosed to amphibolite (uralitized) and subsequently retrograded to an assemblage of talc and chlorite. Bastite after pyroxene is rare. In feldspar-clinopyroxene cumulates (Sandy Bar Narrows, Occurrence #11, Fig. 6) feldspar is weakly saussuritized (Plate 1D). Fine grained, dense, aggregates of chlorite in the more mafic members of the ultramafic rock units are interpreted to have been derived from feldspar. A tremolite-chlorite felt occurring interstitially between skeletal olivine may originally have been volcanic glass. Magnetite, a product of the serpentinization of olivine is ubiquitous in olivine and occurs as: (a) dustings, (b) concentrations on crystal boundaries and fractures, or (c) parallel trains in "olivine" crystal cumulate (Plate 2A). The parallel orientation of the magnetite trains is thought to be caused by original crystal orientation due to primary layering or to postcumulate tectonic reorientation. Carbonatization altered the serpentinized ultramafic rocks. The intensity of carbonatization appears to be unrelated to the mineralogy of the original rock but may have been controlled by availability of $CO_2$. Carbonatization of ultramafic rocks in Sagawitchewan Bay (Occurrence #2, Fig. 3) resulted in a magnesite-talc rock, with magnesia and lime contents (31.3% MgO, 1.7% CaO) similar to those of the normal serpentinized olivine cumulates (Appendix II). However, many carbonate veins are characterized by depletion of MgO and relative enrichment in CaO (10.5% MgO, 6.8% CaO and 9.4% $FeO^{tot}$). The resultant rock is composed of magnesite, ankerite and calcite.

## SELECTED ULTRAMAFIC OCCURRENCES IN THE ISLAND LAKE AREA*

### LINKLATER ISLAND AREA

In the Linklater Island area of northwestern Island Lake (Fig. 4) the ultramafic rocks are characterized by the occurrence of a) olivine cumulates, b) olivine cumulates containing minor interstitial clinopyroxene or clinopyroxene oikocrysts, c) pyroxenites and d) olivine spinifex.

#### Occurrence #2

Spinifex textured rocks on an island close to the eastern shore of Linklater Island (Occurrence #2, Fig. 4) (Theyer, 1977) are thought to represent the upper levels of an ultramafic volcanic flow (Theyer, 1977). They outcrop in a 1 m x 1 m area on the eastern shore of the island. Randomly oriented olivine needles and blades, 1 to 3 cm long, occur in a partially carbonatized matrix (Plate 2B). Diamond drilling with a GSC drill perpendicular to the outcrop's surface, revealed discontinuous zones of spinifex textured rock (2 - 3 cm thick) separated by dark grey carbonatized rock.

Other textures of volcanic flow rocks such as chilled margins, flow-top breccia or columnar jointing were not observed and thus the stratigraphic orientation of this ultramafic rock unit was not established. The spinifex textured rock is structurally underlain by a carbonatized, fine grained serpentine-talc rock. Outcrops east of the spinifex textured rock consist of dark grey carbonatized rock characterized by randomly oriented fractures containing lenses and veins of talc and carbonate. Thin sections of rocks occurring in the immediate vicinity of the olivine spinifex textured rocks show an olivine orthocumulate with subhedral olivine between 0.1 - 2 mm in diameter. Interstitial spaces, veins and many of the serpentine pseudomorphs after olivine are filled or completely replaced with carbonate. Carbonatization increases east of the spinifex textured zone. Thin sections of rock samples approximately 5 m east of the spinifex textured rock have a carbonatized groundmass, abundant secondary hornblende, minor serpentine and scattered, large (0.5 cm), idiomorphic and partially embayed chromite crystals. Samples collected at 15 m intervals from the northern, northwestern and western shore of Occurrence #2, Figure 4, show densely packed olivine orthocumulates with magnetite in dusty aggregates. Chromite occurs as large, euhedral, commonly embayed crystals.

The spinifex textured rock at Occurrence #2 (Fig. 4) is interpreted to represent the stratigraphically upper part of an ultramafic volcanic flow. Other parts of a volcanic flow are not found at this locality. Their absence may be accounted for by: (a) tectonic truncation; or (b) they may be covered by overburden. Associated mafic volcanic flow rocks and epiclastic sedimentary rocks exhibit faulted and sheared contacts with the ultramafic rocks.

#### Occurrence #3

Ultramafic Occurrence #3 (Fig. 4) is a grey-green tremolite schist outcropping on an island approximately 80 m east of Occurrence #2. The tremolite schist is interpreted as metamorphosed serpentinite (Theyer, 1977) and is thought to be part of Unit I ultramafic rocks. It is in sheared contact with a rock identified by Weber et al. (1982) as felsic tuff and ash flow.

#### Occurrence #4

Occurrence #4 (Fig. 4) is a small exposure in an area of extensive glacial debris. Petrographic examinations indicate an antigoritized olivine cumulate with minor (1%) magnetite. Olivine crystals are randomly oriented, densely packed and subhedral to equant (0.8 - 8 mm).

Ultramafic rocks of Occurrences #5, #6, #7 and #8 are very similar. The samples consist of serpentinized (mainly antigoritized) olivine cumulate (Plate 1A). Serpentine pseudomorphs after olivine are highlighted by magnetite concentrations along crystal edges and fractures. Chromite occurs in euhedral (0.3 - 0.5 mm) crystals.

* A table of important geological features is contained in Appendix I.

### ULTRAMAFIC ROCKS WEST OF LINKLATER ISLAND

Two islands (Occurrence #9) west of Linklater Island (Fig. 4) comprise serpentinized, dark grey to black weathering ultramafic rocks, devoid of carbonate metasomatism and carbonate veining. Petrographic examinations indicate serpentinized olivine orthocumulates with subhedral olivine ranging between (0.5 and 0.8 mm) in a sericite-chlorite-talc matrix. Some thin sections exhibit ragged uralitized pyroxene crystals, as well as olivine phenocrysts measuring up to 1 cm and minor epidote. Crosscutting antigorite veins (1-2 mm) indicate that a second serpentinization event affected these rocks.

Irregularly distributed pyroxene and olivine cumulate rocks outcrop on the mainland west of Linklater Island (Fig. 4). These rocks vary from pyroxenite to melagabbro containing feldspar and olivine. Pyroxene occurs as large (8-12 mm) subhedral to anhedral amphibolitized crystals surrounded by saussuritized and chloritized plagioclase laths. Magnetite is dispersed in cloudy aggregates, and in veinlets. There are minor variations in pyroxene content and crystal size; however, these variations are random and thus preclude a determination of flow direction or primary layering. The northern edge of this ultramafic to mafic body is in faulted contact with epiclastic sedimentary rocks. The west and south contacts are covered by overburden.

### FLEET POINT

Fleet Point is part of a peninsula west of Linklater Island (Fig. 4). The northernmost ultramafic occurrence (Occurrence #11) is a dark green talc schist with a rough knobby weathered surface. This approximately 70 m wide exposure is separated from an adjacent altered gabbro by a fault zone. Thin sections exhibit talc in lensoid aggregates that resemble pseudomorphs after pyroxene. Chlorite may have been derived from the alteration of feldspar. The adjacent gabbro shows saussuritization of feldspar, as well as amphibolitization and chloritization of pyroxene. The talc schist appears to have resulted from intense talc metasomatism and carbonatization of a pyroxenitic layer within the gabbro.

The southern ultramafic occurrence (Fig. 4) is a densely packed olivine orthocumulate comprising minor amounts of clinopyroxene, talc and chlorite. Magnetite occurs as dustings and concentrations along edges and fissures of generally well preserved subhedral olivine crystals (0.2 - 1.2 mm). This ultramafic rock is in faulted contact with adjacent sediments.

### ULTRAMAFIC ROCKS SOUTH OF LINKLATER ISLAND

Four small islands situated south of Linklater Island (Occurrence #13, Fig. 4) comprise ultramafic rocks that are characterized by large (up to 13 mm) well preserved olivine (Fo 92.5 ± 0.5%). Chromite occurs sporadically as large (0.5 - 1 mm) euhedral but embayed crystals. Discrete, 5 - 10 cm thick fracture controlled carbonate veins are rimmed by 3 - 5 cm thick talc alteration. Asbestos occurs as 5 - 10 mm wide veins.

Other ultramafic rocks in the Linklater Island area are rocks described as "peridotite" (associated with tuff and granite) that were intersected by diamond drilling on the eastern side of central Linklater Island (Manitoba MRD Assessment File 99283).

### STEVENSON ISLAND AREA

The Stevenson Island area in west-central Island Lake (Fig. 3) includes three groups of ultramafic lenses.

#### "Trinity Shoals" (Occurrence #1)

Occurrence #1 (Fig. 3) or "Trinity Shoals", comprises three islands 3 km northwest of Stevenson Island (Fig. 5). Petrographic studies indicate dunite composed of only partially serpentinized, subhedral, equant to elongated olivine (0.1 to 3 mm) embedded in chlorite. Clinopyroxene

oikocrysts enclose olivine. Magnetite 'dust' is concentrated on edges and fractures of olivine. Chromite occurs as rare, subhedral to euhedral crystals (0.1 - 0.2 mm). These rocks resemble the olivine cumulates described from south of Linklater Island (Occurrence #13, Fig. 4). However, a ground magnetometer survey (Man. MRD Assessment File 99272) indicates that these ultramafic occurrences are not connected.

Occurrence #3 (Fig. 5) locally known as "Pipestone Quarry" is a serpentinized olivine cumulate with minor interstitial chloritized pyroxene. It is in faulted association with gabbro and a detrital sedimentary rock series comprising black slates, greywacke, quartzite and chert.

Occurrence #4 (Fig. 5) consists of two isolated islands underlain by carbonatized olivine cumulate. Occurrences #5 and #6 (Fig. 5) are peridotite containing altered clinopyroxene oikocrysts and olivine cumulate in association with detrital sediments thought to be equivalent to the sedimentary rocks associated with Occurrence #3.

**Jubilee Island (Occurrence #2)**

Ultramafic rocks (Occurrence #2, Fig. 5) were identified on Jubilee Island (P. Gilbert, pers. comm. 1982). They consist of two approximately 6 m thick layers of carbonatized peridotite in faulted contact with hornblendite and amphibolite. Petrographic examinations indicate the peridotite comprises subhedral pseudomorphs of antigorite after olivine ranging between 0.1 - 1 mm in size, amphibolitized pyroxene, chlorite and accessory magnetite.

## SANDY BAR NARROWS AREA

Sandy Bar Narrows is situated at the western end of Sagawitchewan Bay. For the purpose of this report it also includes several islands to the west and northwest of Loonfoot Island (Fig. 6).

Sandy Bar Narrows, i.e., the western end of Sagawitchewan Bay, includes several ultramafic rock lenses. A geological sketch map of this area (Fig. 7) shows that the ultramafic rocks are in association with epiclastic sedimentary rocks, mafic to felsic volcanic rocks and mafic intrusive rocks. Evidence of shear folding and stratigraphic considerations suggest that the ultramafic rock is tectonically concentrated at the hinges of large shear folds.

The ultramafic rocks of this area comprise (1) olivine orthocumulate; (2) olivine cumulate containing up to 15% aphanitic matrix; (3) clinopyroxene cumulate; and (4) feldspar-clinopyroxene cumulate with a gabbroic texture. Pyroxene is amphibolitized or serpentinized to bastite. The interstitial matrix is commonly a fine grained serpentine-talc-chlorite intergrowth.

The composition of these ultramafic rocks varies within a few metres. Occurrence #4 (Fig. 6) is an olivine cumulate lens associated with felsic volcanic rocks. The contact with these rocks is an approximately 5 m wide sheared zone of talc-carbonate-chlorite schist that changes gradually into an undeformed carbonatized olivine cumulate. Occurrence #6 (Fig. 6) occupies part of an island (150 m x 40 m) underlain by ultramafic rocks that range from olivine cumulate (Plates 2C and 2D) to olivine clinopyroxene orthocumulate with approximately 10% clinopyroxene (Plate 3A). A 10 cm thick, crosscutting, fine grained homogeneous dyke composed of serpentine is interpreted as having formed by hydraulic fracturing and autoinjection in solidifying ultramafic rocks such as described by Nicholas and Jackson (1978).

Occurrences #10 and #11 (Fig. 6) outcrop on one island. Occurrence #10 is a rock lens at the southwest portion of the island, whereas Occurrence #11 consists of two discrete but compositionally similar outcrops located at the northwest and northeast corners of this island. Geological contacts are, with one exception, sheared or faulted. The undisturbed contact is found on the northeastern outcrop of Occurrence #11. It separates clinopyroxene cumulate (Plate 3B) and an ophitic gabbroic rock containing ragged, lath-shaped plagioclase and subordinate subhedral clinopyroxene (Plate 3C). The increase in the amount of clinopyroxene and chromite in the direction of the ultramafic portion of this outcrop results in a rock containing cumulate clinopyroxene, chromite and minor ragged and saussuritized lath-shaped feldspar. Chromite generally occurs in small (1 mm) clusters of up to 20 individual euhedral chromite crystals (Plate 3C); this distribution habit was not seen elsewhere in the ultramafic rocks of Island Lake. A 2 - 3 cm thick, dark grey to black rock layer containing high chromite concentrations (14,000 ppm Cr) separates the gabbroic portion from the virtually monomineralic uralitized clinopyroxene cumulate of this occurrence.

The western exposure of Occurrence #11 is a dark grey to black, smoothly weathered, fine- to coarse-grained rock in sheared contact with adjacent felsic to intermediate volcanic flows. Petrographic examinations reveal a clinopyroxene cumulate (Plate 1D) that resembles the clinopyroxene cumulate of the eastern part of Occurrence #11. It is associated with poikilitic olivine cumulate containing abundant clinopyroxene oikocrysts.

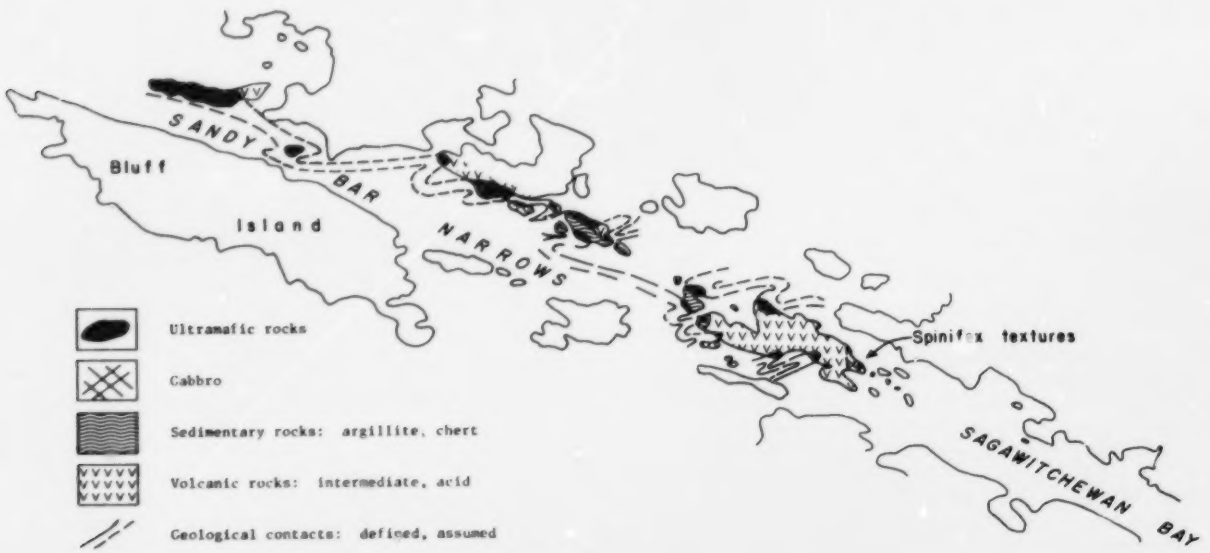


*FIGURE 7: Geological sketch-map of the Sandy Bar Narrows area.*

The ultramafic rocks of Occurrence #12 (Fig. 6) are intensely carbonatized and include up to 5% hematite crystals that give the rock a peculiar blue to black mottled appearance which is readily visible on weathered surfaces. Pervasive regional carbonate metasomatism also affects the adjoining volcanic rocks for several hundred metres away from the ultramafic lens. Petrographic examinations reveal a fine grained carbonate matrix with rare, ragged serpentine patches. A primary ultramafic composition for this rock is inferred based on the occurrence of serpentine and abundant hematite.

The ultramafic rocks of Occurrence #13 outcrop on a reef north of Loonfoot Island (Fig. 6). They comprise yellow-green weathering, dense, fine grained carbonate-antigorite lenses and veins with disseminated pyrite (0.5 - 1%). Petrographic examinations reveal a dense olivine cumulate with individual subhedral olivine (up to 5 mm) embedded in magnetite and chromite. Olivine crystals have a subparallel orientation which is thought to be a primary texture. Several distinctive pale green coloured, approximately one metre long, dense and hard rock lenses, are randomly distributed in this outcrop. They are composed of a carbonate matrix with antigorite and minor chromite.

**SAGAWITCHEWAN BAY AREA**

Sagawitchewan Bay (Fig. 8) is an approximately 14 km long, narrow (500 - 1000 m) inlet of eastern Island Lake; it adjoins the Sandy Bar Narrows area (Fig. 3).

The northern and southern shores of Sagawitchewan Bay are underlain by mafic to intermediate volcanic rocks, pillowed volcanic flows, volcanic breccias and tuff. These rocks are intruded in several areas by gabbroic stocks. Many of the islands within Sagawitchewan Bay are underlain by epiclastic sedimentary rocks including gritty argillite, slate, greywacke and 2 - 3 m thick layers of quartz pebble conglomerate. These rocks appear to be part of a rock sequence that occupies the centre of Sagawitchewan Bay. East-trending foliation and shearing transposed and partially obliterated a sporadically preserved north-trending (primary?) layering.

In Sagawitchewan Bay islands that are underlain by ultramafic rocks (Fig. 8) are characterized by rocks with rounded, grey-green weathering surfaces with a rough gritty texture caused by large (0.5 - 2 mm), weathered serpentine pseudomorphs. Magnetite in Occurrences #2 and #3 appears as 2 - 3 cm thick veins and fist-sized pods with ilmenite and hematite. Intense carbonatization was observed at Occurrence #3 (Fig. 8). The southeastern third of this island is completely carbonatized. A sharply defined boundary divides the serpentinized olivine cumulate rock from the carbonatized rock.

The ultramafic rocks found in Sagawitchewan Bay are, with the exception of Occurrence #6 (Fig. 8), olivine cumulates. Olivine constitutes approximately 90 - 98% of the rock by volume. It occurs as subhedral crystals ranging from 0.1 to 10 mm in size but does not exhibit any evidence of layering or grain size sorting. Magnetite is present locally as parallel enrichment trains. Subhedral to anhedral clinopyroxene ranging from 0 - 9% by volume occurs (1) interstitial to olivine, (2) as cumulate crystals, or (3) as large (10 mm) oikocrysts enclosing olivine. Clinopyroxene is uralitized and altered to a tremolite-chlorite intergrowth. Chromite (1 - 2% by volume) occurs as small (0.1 - 0.3 mm) euhedral crystals and sporadically as larger (up to 1 mm) subhedral crystals with lobate, embayed and amoeboidal shaped edges.

**Spinifex Textured Ultramafic Rocks in Sagawitchewan Bay**

Ultramafic Occurrence #6 (Fig. 8) comprises olivine and olivine-clinopyroxene cumulate rocks, two discrete ultramafic volcanic flows and spinifex-textured flow top rubble breccia (Fig. 9). This island measures approximately 180 by 70 m and has excellent shoreline exposures. The northern shore is underlain by a light grey-green weathering, carbonatized and foliated pyroxenitic rock. The eastern and southern shore is underlain by dark grey weathering olivine cumulate. The rocks of the northwestern shore are very fine grained, homogeneous, dark grey and smooth weathering, and are crosscut by sinuous fractures with a yellow-grey hard, brittle chlorite-tremolite-carbonate rock.

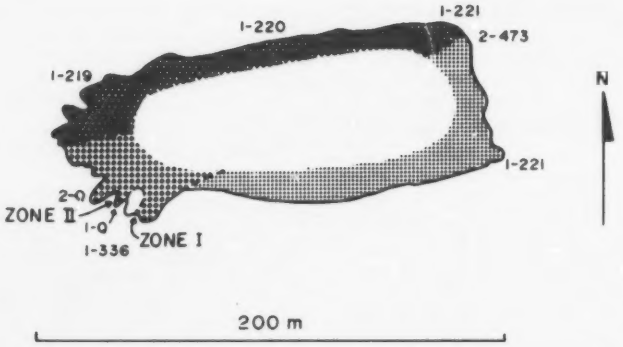


*FIGURE 9: Geological sketch map of ultramafic occurrence #6 (Sagawitchewan Bay area).*

Petrographic studies reveal a carbonatized and tremolitized cumulate pyroxenite comprising up to 50% plagioclase and minor talc (Plate 1D). Positive identification of relict textures resembling pyroxene spinifex observed in one thin section was not possible due to the effects of alteration. The central portion of the island, as well as its eastern and southern shore are underlain by a dark grey to black, olivine cumulate that contains densely packed, serpentine (antigorite) pseudomorphs after olivine in a carbonate-talc matrix ranging from 0.2 to 12 mm within thin sections. Magnetite occurs as dustings and concentrations along crystal rims and fractures, or in parallel trains within the olivine (Plate 2A).

Spinifex textures occur in exposures on the southwestern part of the island. The spinifex textured rocks were subdivided into two zones based on their appearance, type and composition (Fig. 9). Zone I includes two east-striking, approximately 1 m high ridges of rubble breccia. This rock, composed of angular fragments ranging from 1 mm to 4 cm in size is interpreted as a flow top breccia (Plate 4A). Arndt et al. (1977) described similar rocks as the chilled, brittle skin of a volcanic flow in which the fragments separated at a high temperature and were then rewelded in their final emplacement position. The resulting rock is a low density, honeycombed, rubble breccia similar to that of Zone I. Many of the fragments include short (up to 1 cm) irregularly oriented pyroxene spinifex lamellae in a light green chlorite-talc matrix (Plate 4B).

Zone I rocks are separated from the olivine spinifex of Zone II by approximately 5 m of overburden. Zone II rocks can be subdivided into three units based on the shape, arrangement and size of the skeletal olivine. Unit I olivine spinifex lamellae measure up to 20 cm in length by 2 - 3 mm thickness and are oriented in conical- and fan-shaped sheaf like aggregates. These sheaves are bent, kinked and sporadically separated by small carbonate-filled lenses (Plate 4C). Unit II spinifex, exposed along 7 m of shoreline, is characterized by the absence of the deformation typical of Unit I. Elongated (20 cm long) skeletal olivine blades are arranged in fan-shapes and conical booklet patterns (Plate 4D). Unit II spinifex textures are comparable to those of Zone $A_s$ of a spinifex textured volcanic flow (Pyke et al, 1973). Unit III is an approximately 5 m wide outcrop occurring north of Unit II. It is characterized by short, randomly distributed olivine spinifex lamellae (2 - 3 cm).

Arndt et al. (1977) showed that, in general, the average size of spinifex lamellae increases towards the stratigraphic base of a spinifex textured volcanic rock flow. Short and thin bladed randomly oriented spinifex lamellae occur typically near the top of spinifex textured volcanic rock flows (Lajoie and Gélinas 1976). Since there is an increase in length of spinifex lamellae to the south, it is proposed that the stratigraphic top of the olivine spinifex textured volcanic flow is to the north. The occurrence of pyroxene and olivine spinifex textured rocks in proximity suggests that two discrete, ultramafic volcanic flows are

present on this island (Fig. 9). Faulting, truncation and tectonic rearrangement of rock units may account for the apparently missing units which are considered to form part of a complete volcanic flow (Pyke et al., 1973) and for the atypical rock distribution; for example, pyroxene spinifex textured flow top breccia is located adjacent to an olivine spinifex textured volcanic flow.

### HENDERSON ISLAND

The presence of an elongate (200 - 300 m long by 80 m wide) ultramafic body is inferred from: a) the outline and intensity of a magnetic anomaly (Fig. 10), and b) the sporadic occurrence of sheared and distorted ultramafic rocks. The magnetic anomaly is centered over a graben defined by two subparallel 10 to 30 m high escarpments about 80 m apart. The bottom of this graben is covered by coarse rubble; however, remnants of ultramafic lenses occur on both escarpments.

Petrographic studies reveal carbonatized, deformed and rounded nodules of a serpentine-chlorite intergrowth and ragged, subhedral pyroxene in a fine grained carbonate-chlorite-talc groundmass. Dendritic and spiral appendages and internal concentric zones indicate that these nodules accreted out of a comminuted carbonatized serpentine mass during intense deformation. These ultramafic tectonites are in sheared contact with fragmental felsic volcanic rock to the north and amphibolite to the south. Gilbert and Weber (1983), however, interpret portions of these ultramafic rocks as megaporphyritic olivine melagabbronorite.

## GEOCHEMISTRY OF ULTRAMAFIC AND RELATED ROCKS

Ultramafic and related rocks (48 specimens) were analyzed in the Analytical Laboratories of the Manitoba Department of Energy and Mines, Mineral Resources Division. Sample locations and numbers are shown on the geological maps (Figs. 4 to 10). Appendix II contains a listing of analytical data and "normalized" analytical data for selected ultramafic rocks. Most diagrams were drawn using "normalized" data, i.e., data from which volatiles and sulphides were extracted.

The normalized data without the sulphides and volatiles that presumably were added during magma emplacement or metamorphism are postulated to approximate the composition of the parental magma. The normalization process consists of removing copper, iron and sulphur as chalcopyrite ($CuFeS_2$), and subsequently removing nickel, iron and sulphur as pentlandite ($Ni_{4.5}Fe_{4.5}S_8$). Any remaining sulphur is then removed with iron as pyrrhotite ($Fe_7S_8$). The remaining iron is then subdivided into ferrous and ferric iron according to the ratio $Fe_2O_3$ = % $TiO_2$ + 1.5 (Irvine and Baragar, 1971). After removing $CO_2$ and $H_2O$ the oxides are then recalculated to a total of 100%.

Serpentinization is considered to affect the chemistry of ultramafic rocks since it involves the intake of large amounts of water into the ultramafic rock resulting, in the case of an isochemical transformation, in corresponding rock volume increases (Thayer, 1966). An alternative model, the constant volume process, envisages the intake of water to be compensated by a corresponding transfer of the oxides MgO, CaO, FeO, and $SiO_2$ out of the serpentinizing ultramafic rock unit. The preservation of original textures in many of the ultramafic rocks of Island Lake suggests that serpentinization was probably an equal volume process.

Chemical analyses of rocks containing cumulate crystal phases will be biased in their composition, e.g., olivine cumulate rocks will have higher MgO contents than the parental magma. Therefore the composition of the cumulate rocks alone cannot be used directly to establish the parentage of the ultramafic magma.

### GEOCHEMISTRY

The average Island Lake olivine cumulate and olivine spinifex rock are, with exception of the lime contents, comparable to the average chemistry of similar rocks in other areas (Table 2). The average MgO contents of the ultramafic rocks from Island Lake (39.39% MgO) places them at the peridotite/dunite boundary according to the classification by Naldrett and Cabri (1976).

The analytical data are separated into three sample groups that correspond to the geographic domains shown on Figure 11: a) Linklater Island; b) Sandy Bar Narrows; c) Sagawitchewan Bay. Each data group is plotted on an individual diagram in order to test the data sets for regional geochemical patterns.

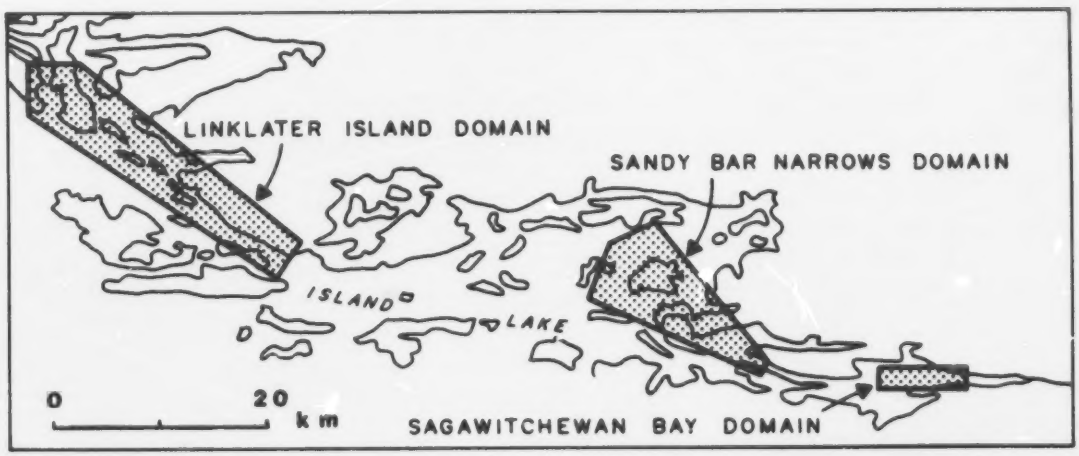


*FIGURE 11: Outline of areas of lithogeochemical surveys (see Appendix II).*

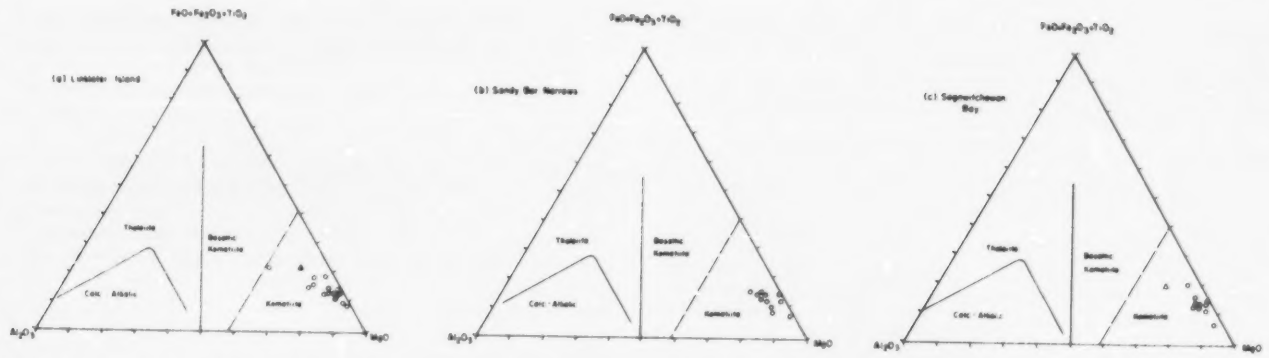


*FIGURE 12: $Al_2O_3$ vs ($FeO + Fe_2O_3 + TiO_2$) vs MgO diagrams; (a) Linklater Island; (b) Sandy Bar Narrows; (c) Sagawitchewan Bay, to illustrate variations in ultramafic rocks (see text)*
*circles - ultramafic rocks with normal textures*
*open triangle - spinifex textured ultramafic rock - Sagawitchewan Bay*
*closed triangle - spinifex textured ultramafic rock - Linklater Island.*

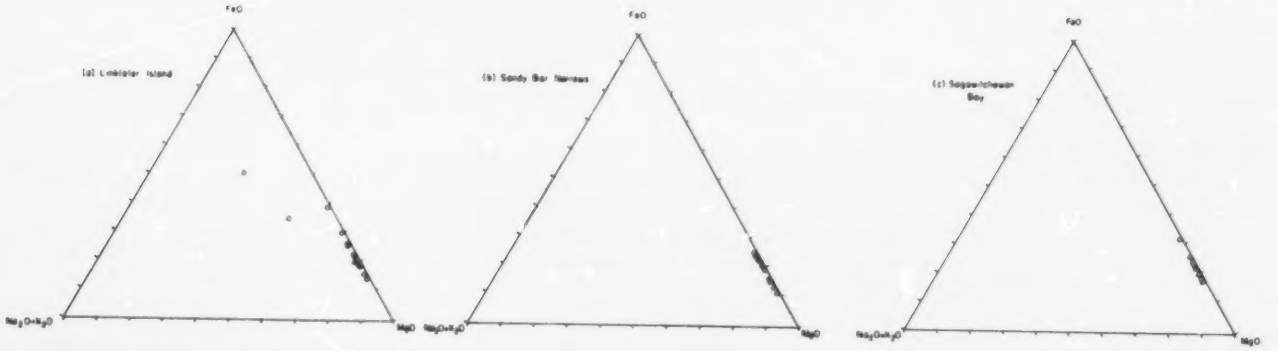


*FIGURE 13: ($Na_2O + K_2O$) vs FeO vs MgO diagrams; (a) Linklater Island; (b) Sandy Bar Narrows; (c) Sagawitchewan Bay, illustrating alkali impoverishment (see text). Symbols as in Figure 12.*

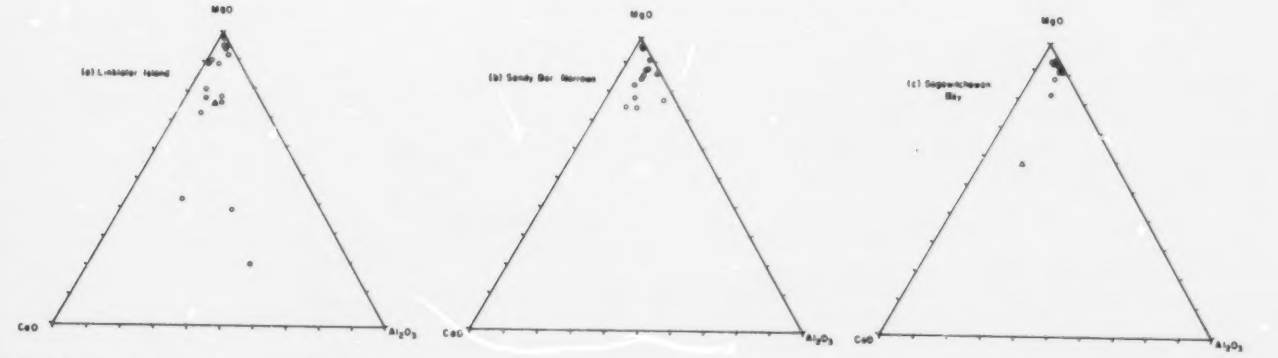


*FIGURE 14: CaO vs MgO vs $Al_2O_3$ diagrams; (a) Linklater Island; (b) Sandy Bar Narrows; (c) Sagawitchewan Bay, showing dominance of MgO from olivine (see text). Symbols as in Figure 12.*

The "komatiitic" chemistry may be deduced from the ternary diagram $Al_2O_3$ vs. FeO + $Fe_2O_3$ + $TiO_2$ vs. MgO; (Jensen diagram). Most of the samples plot in the high MgO, peridotitic komatiite field. Samples containing less MgO plot in the basaltic komatiitic field along a curvilinear trend that coincides with Jensen's "komatiitic trend" (Jensen 1976). The Jensen diagrams (Figure 12) do not indicate any obvious regional variations.

The AFM ($Na_2O$ + $K_2O$) vs. FeO vs. MgO diagrams (Fig. 13) show a uniform sample distribution along the iron-magnesia line indicating alkali impoverishment. The strong olivine control on the chemistry is indicated in the CMA (CaO vs. MgO vs. $Al_2O_3$) diagrams (Fig. 14) by the consistent dominance of MgO in all three domains. A trend towards the $Al_2O_3$ field coupled with decreasing MgO content in the Sagawitchewan Bay CMA diagram is interpreted to be the result of CaO depletion.

A binary diagram showing $Al_2O_3$ vs. FeO/(FeO + MgO) was used by Arndt et al. (1977) to distinguish between komatiitic and tholeiitic rocks in Munro township, Ontario. The majority of the Island Lake samples plot in the komatiitic field; however, eight samples plot in the tholeiitic field (Fig. 15). There are two explanations for this: a) Samples that contain above 3% $Al_2O_3$ represent true tholeiites; b) Samples that contain less than 2% $Al_2O_3$ plot in the tholeiite field due to the weakness of this diagram to discriminate between low alumina komatiites and tholeiites.

Figure 16 suggests an inverse relationship between $TiO_2$ and $Cr_2O_3$. The $TiO_2$ content of a magma is inversely proportional to the degree of melting of the parental rocks, i.e., all available $TiO_2$ is contained in the melt at melting rates as low as 15% and becomes progressively diluted at increasing degrees of melting (Nesbitt and Sun, 1976; Nesbitt et al., 1979). Ubiquitous of chrome spinel (1-2% by volume) and sporadic clinopyroxene, an alternative carrier of Cr, suggest that all Cr is contained in chromite. Figures 17(a) and (b) show the ratio of MgO vs. Ni and MgO vs. Cr. The variation of MgO from 30% to 45%

**TABLE 2**

**Representative analyses of ultramafic rocks from the Island Lake area and Munro Township[1]**

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| $SiO_2$ | 43.8 | 44.9 | 44.0 | 45.6 | 44.9 |
| $Al_2O_3$ | 3.05 | 4.23 | 4.1 | 7.35 | 5.3 |
| $Fe_2O_3$ | 5.5 | 4.5 | 9.0* | 11.7* | 10.4* |
| FeO | 6.18 | 5.4 | | | |
| CaO | 1.18 | 6.08 | 3.61 | 7.62 | 5.0 |
| MgO | 39.39 | 31.28 | 38.6 | 25.9 | 33.6 |
| $Na_2O$ | 0.01 | 0.02 | 0.08 | 0.83 | 0.35 |
| $K_2O$ | 0.02 | 0.03 | 0.11 | 0.06 | 0.08 |
| $TiO_2$ | 0.12 | 0.27 | 0.15 | 0.27 | 0.19 |
| $P_2O_5$ | 0.03 | 0.09 | | | |
| MnO | 0.14 | 0.17 | 0.16 | 0.21 | 0.18 |
| NiO | | | 0.03 | 0.17 | 0.02 |
| $Cr_2O_3$ | | 0.28 | 0.41 | 0.26 | |
| Cr | 4320 | n.d. | 1762 | — | |
| Co | n.d. | n.d. | 118 | — | |
| Ni | 1980 | n.d. | 2290 | — | |
| Cu | 18 | n.d. | n.d. | — | |
| Pb | 3 | n.d. | — | | |
| Zn | 50 | n.d. | 54 | — | |
| Rb | 2 | n.d. | 3 | — | |
| Sr | 11 | n.d. | 6 | — | |
| Ba | 30 | n.d. | n.d. | — | |

NOTES: Analyses are recalculated on an anhydrous basis. Samples 1 and 2 are "normalized". (See section on "Geochemistry" for description of the procedure).

1. Average of six ultramafic rocks from Island Lake.
2. Spinifex textured peridotitic komatiite from Island Lake (Linklater Island) (Sample 51-8-0-5).
3. Cumulate peridotite of peridotitic komatiite flow (Sample 79-119).
4. Spinifex textured peridotitic komatiite (Sample SA 1048).
5. Average composition of peridotitic komatiites with MgO contents more than 30%.

1) Columns 3, 4, and 5 are from Arndt et al. (1977, Table 7, p. 352-353).

* FeO + $Fe_2O_3$

## TABLE 3

### Trace element contents of olivine cumulates from the Island Lake area

| Sample Number | 137 | 153 | 155 | 203 | 207 | 213 | 214 | 217 | 219 |
|---|---|---|---|---|---|---|---|---|---|
| Cu | 20 | 10 | 38 | 172 | 520 | 13 | 2 | 2 | 50 |
| Ni | 1450 | 1650 | 1700 | 3880 | 6800 | 2110 | 2110 | 1810 | 1040 |
| Pb | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Zn | 77 | 46 | 33 | 45 | 38 | 24 | 27 | 23 | 36 |
| Cr | 2500 | 4150 | 4200 | 4500 | 1650 | 4450 | 5100 | 4500 | 4250 |
| Rb | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Sr | 30 | 30 | 65 | 50 | 15 | 5 | 25 | 10 | 10 |
| Ba | 70 | 70 | 30 | 30 | 40 | 30 | 20 | 40 | 20 |

| Sample Number | 222 | 226 | 259 | 261 | 266 | 274 | 276 |
|---|---|---|---|---|---|---|---|
| Cu | 5 | 1 | 3 | 53 | 14 | 6 | 152 |
| Ni | 2140 | 1470 | 1950 | 1950 | 2050 | 2160 | 1870 |
| Pb | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Zn | 43 | 22 | 43 | 56 | 39 | 45 | 53 |
| Cr | 2750 | 4650 | 4950 | 4250 | 4200 | 4250 | 4150 |
| Rb | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Sr | 25 | 5 | 45 | 5 | 5 | 5 | 5 |
| Ba | 20 | 20 | 40 | 40 | 30 | 20 | 10 |

| Sample Number | 279 | 289 | 290 | 292 | 312 | 313 | 314 | 315 | 324 | 325 | 329 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cu | 36 | 15 | 22 | 25 | 5 | 3 | 13 | 17 | 5 | 15 | 3 |
| Ni | 1840 | 1960 | 2230 | 1500 | 1990 | 2250 | 1960 | 2090 | 2040 | 1380 | 2140 |
| Pb | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Zn | 48 | 57 | 37 | 65 | 53 | 38 | 36 | 33 | 48 | 62 | 41 |
| Cr | 4550 | 4700 | 4150 | 4050 | 4050 | 4150 | 3600 | 4450 | 4250 | 5100 | 4000 |
| Rb | 2 | 2 | 2 | 4 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Sr | 10 | 5 | 5 | 10 | 10 | 5 | 5 | 5 | 10 | 5 | 5 |
| Ba | 10 | 40 | 10 | 60 | 40 | 50 | 20 | 40 | 30 | 20 | 50 |

| Sample Number | 333 | 334 | 340 | 350 | 352 | 353 | 363 |
|---|---|---|---|---|---|---|---|
| Cu | 59 | 24 | 6 | 16 | 4 | 10 | 153 |
| Ni | 1990 | 1960 | 1600 | 2730 | 1620 | 2040 | 5300 |
| Pb | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Zn | 45 | 41 | 45 | 53 | 60 | 71 | 65 |
| Cr | 4850 | 4150 | 4850 | 4800 | 3150 | 3850 | 2850 |
| Rb | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Sr | 5 | 10 | 5 | 5 | 20 | 10 | 5 |
| Ba | 40 | 40 | 40 | 30 | 40 | 40 | 40 |

**TABLE 4**

**CIPW — Cation Equivalent Norms of Representative Ultramafic Rocks from the Island Lake area**

| CIPW Norm | 51-8-0-5 | 51-8-19 |
|---|---|---|
| Q | — | — |
| C | — | 1.43 |
| Or | 0.21 | 0.14 |
| Ab | 0.20 | 0.10 |
| An | 11.75 | 1.07 |
| Di | 13.85 | — |
| Hé | 0.90 | — |
| En | 29.63 | 34.44 |
| Fs | 2.21 | — |
| Fo | 31.01 | 49.37 |
| Fa | 2.55 | — |
| Mt | 6.74 | 8.63 |
| Il | 0.54 | 0.16 |
| Cr | — | — |
| Ap | 0.22 | 0.05 |
| Py | 0.27 | — |

51-8-0-5: Serpentinized olivine spinifex textured ultramafic (Linklater Island).

51-8-19: Serpentinized olivine cumulate.

is postulated to be due to variations of olivine packing density rather than variations of the MgO contents of olivine. Nickel occurs either within the lattice of olivine in concentrations of 1000 to 3000 ppm, or in combination with iron sulphides. The partitioning ratio of nickel between olivine and the melt is related to the $fO_2$ of the melt and its temperature (Rajamani and Naldrett, 1978; Boctor, 1982). From geological and petrological data it is concluded that Unit I ultramafic rocks originated from a single parental melt. The $fO_2$, the temperature, and the content of Ni in olivine of all the ultramafic rocks of Unit I should be similar. Variations in silica-bound Ni content of samples would be attributable to fluctuations in the olivine content which in turn should be reflected by the MgO content. However, Figure 17a shows a static Ni content (less than 2000 ppm) that is unrelated to the MgO content of the samples. A reason for this phenomenon, other than redistribution of MgO or Ni during metamorphism, is not apparent. Sulphurization as a redistribution mechanism is ruled out, because of the paucity of sulphides observed in the ultramafic rocks. Visible sulphides occur in only two samples and these contain approximately 4000 and 5000 ppm Ni. These conclusions are necessarily tentative due to the sparsity of data on the geological interrelation of the ultramafic rocks.

A correlation between MgO and Cr is evident from Figure 17(b). Chromium is considered to be almost entirely contained in spinels whereas the MgO content depends on olivine composition and olivine crystal packing density. Since MgO contents are probably a result of the packing density of olivine in cumulate rocks by gravitational settling it follows that the higher chrome spinel contents are also derived by cumulate processes (Worst, 1960; Jackson, 1961, 1963; Irvine, 1965).

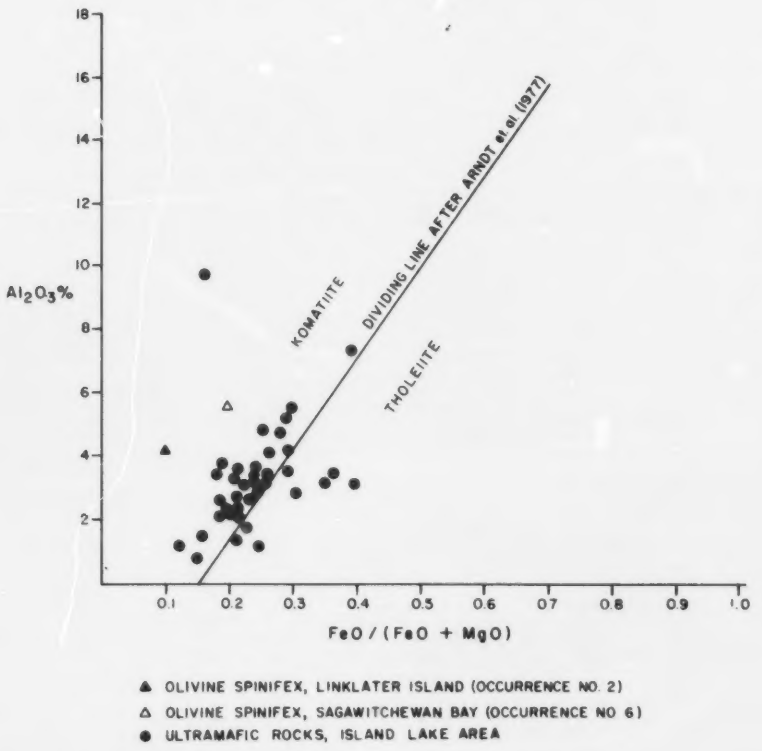


*FIGURE 15. $Al_2O_3$ vs FeO/(FeO + MgO) diagram, showing komatiitic and tholeiitic fields.*

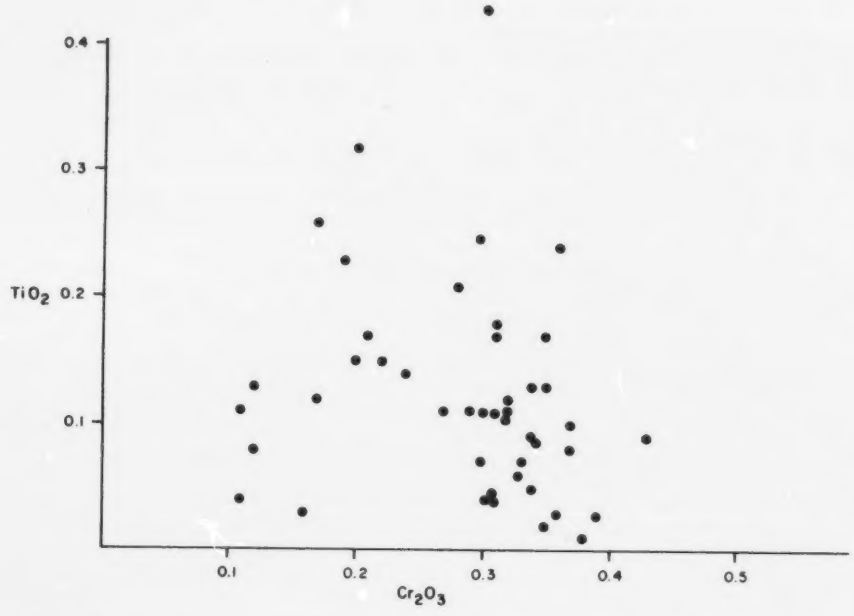


*FIGURE 16: $TiO_2$ vs $Cr_2O_3$ diagram, illustrating possible inverse relationship between $TiO_2$ and $Cr_2O_3$.*

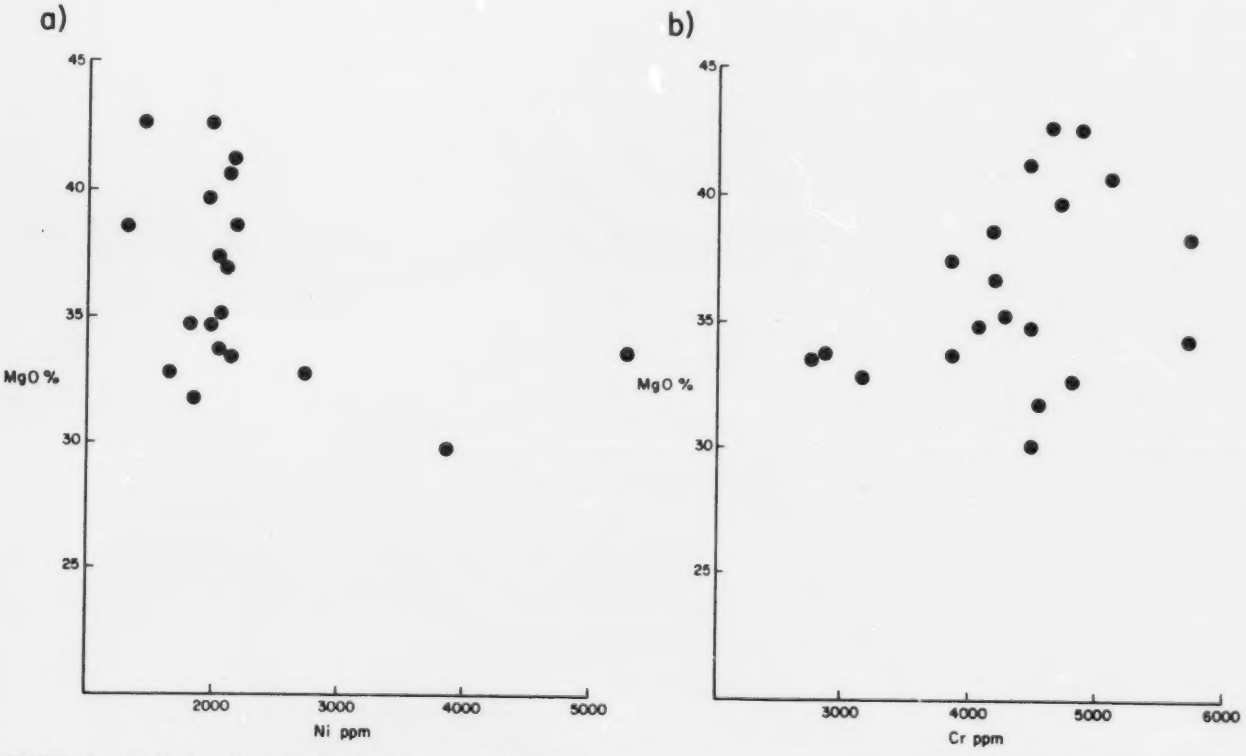


*FIGURE 17: (a) MgO vs Ni; (b) MgO vs Cr diagrams; a) MgO vs Ni diagram: note relatively stable Ni content versus variable MgO content; b) MgO vs Cr diagram: note correlation between MgO and Cr, believed to be caused by cumulate processes.*

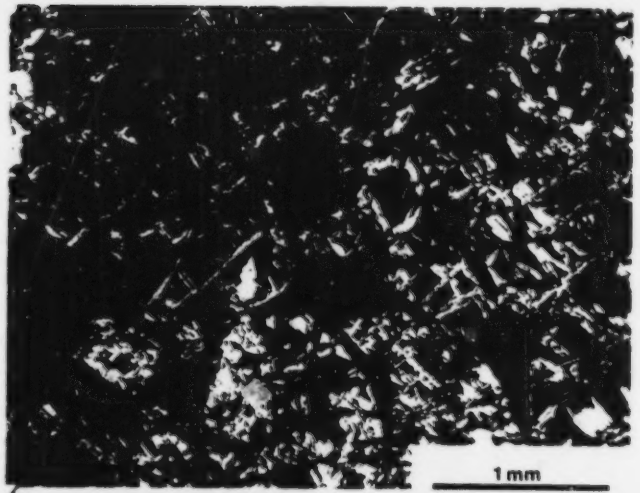


Plate 1A: *Photomicrograph of typical olivine cumulate (sample 1-294, Sandy Bar Narrows, Occurrence #11). Densely packed subhedral serpentine pseudomorphs after olivine. Mesh-textured lizardite and other unidentified serpentine (crossed nicols).*

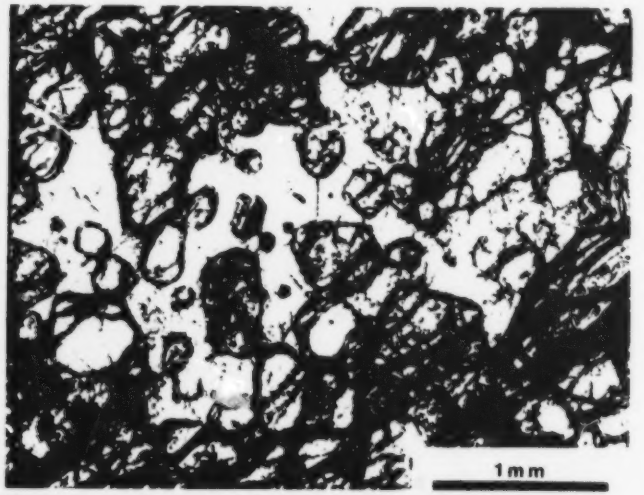


Plate 1B: *Photomicrograph of serpentinized olivine cumulate (sample 1-261, Sandy Bar Narrows, Occurrence #2). Large (more than 3 mm) clinopyroxene oikocrysts enclosing subhedral granular olivine. Serpentine pseudomorphs after olivine show post-cumulate rimming with serpentine of different refractive index and chlorite. Interstitial spaces occupied by chlorite (crossed nicols).*



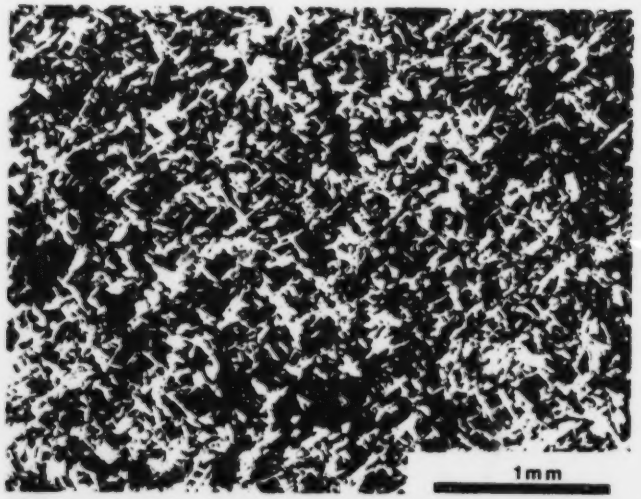


Plate 1C: *Photomicrograph of antigorite felt (sample 7-124, Linklater Island, Occurrence #8). Subhedral olivine shapes recognizable in plain light. Euhedral scattered chromite (crossed nicols).*

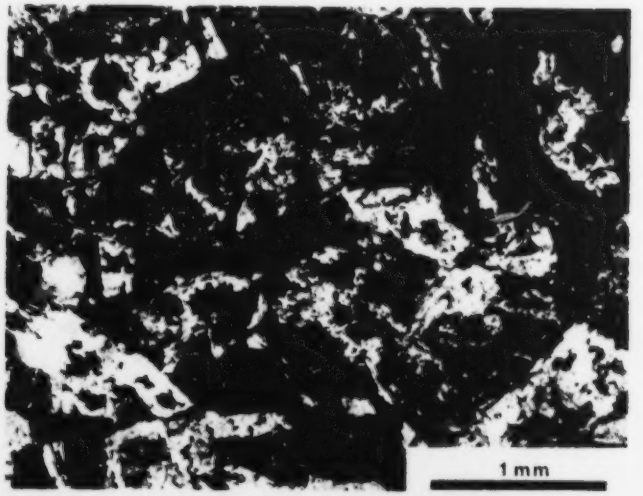


Plate 1D: *Photomicrograph of pyroxene cumulate (sample 1-221, Sagawitchewan Bay, Occurrence #6). Ragged, partially amphibolitized clinopyroxene and approximately 50% plagioclase in vicinity of olivine and pyroxene spinifex (crossed nicols).*

Plate 2A: Photomicrograph of olivine cumulate (sample 1-222, Sagawitchewan Bay, Occurrence #6). Note dense packing of subhedral serpentine pseudomorphs after olivine, and subparallel orientation of magnetite trains in olivine (crossed nicols).

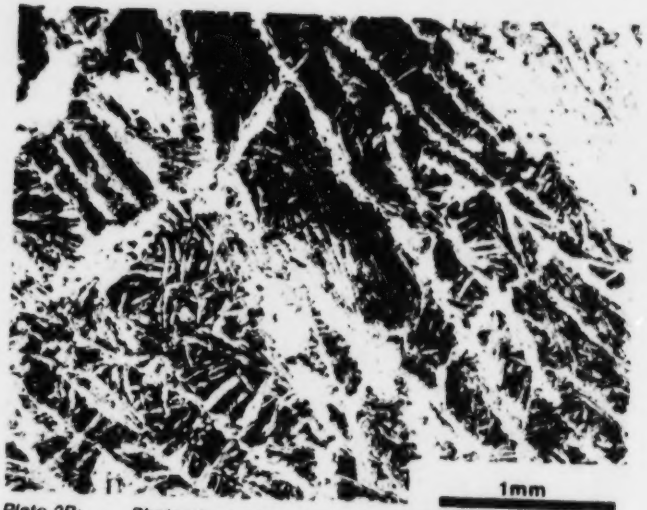


Plate 2B: Photomicrograph of olivine spinifex (sample 1-SPX, Linklater Island, Occurrence #2). Randomly oriented chain and lattice serpentine disturbed by subparallel fractures (crossed nicols).

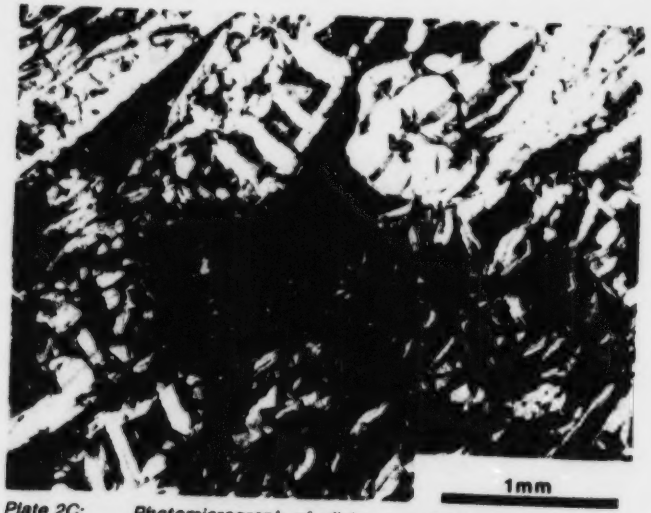


Plate 2C: Photomicrograph of olivine cumulate (sample 1-267, Sandy Bar Narrows, Occurrence #6). Large (1 - 2 mm) subhedral serpentinized olivine with typical hourglass textures. Interstitial spaces occupied by chlorite-talc intergrowth (crossed nicols).

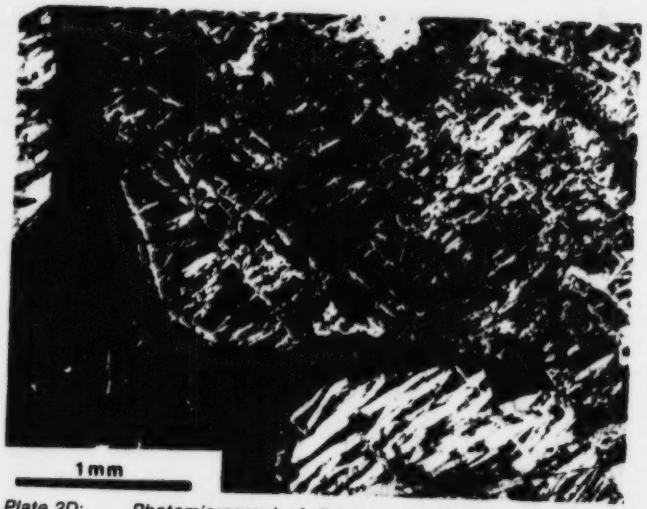


Plate 2D: Photomicrograph of olivine cumulate (sample 1-267, as above). Pseudomorphs after subhedral olivine with typical mesh-textured serpentine (crossed nicols).

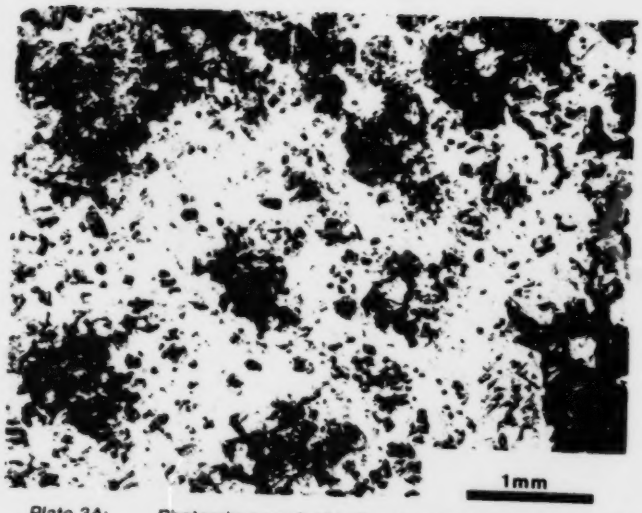


Plate 3A: *Photomicrograph of antigorite pseudomorphs after olivine cumulate containing clinopyroxene oikocrysts, (sample 1-290, Sandy Bar Narrows, Occurrence #11). Clinopyroxene is excellently preserved. Subhedral granular olivine shows faint parallel orientation. Minor magnetite and chromite (crossed nicols).*

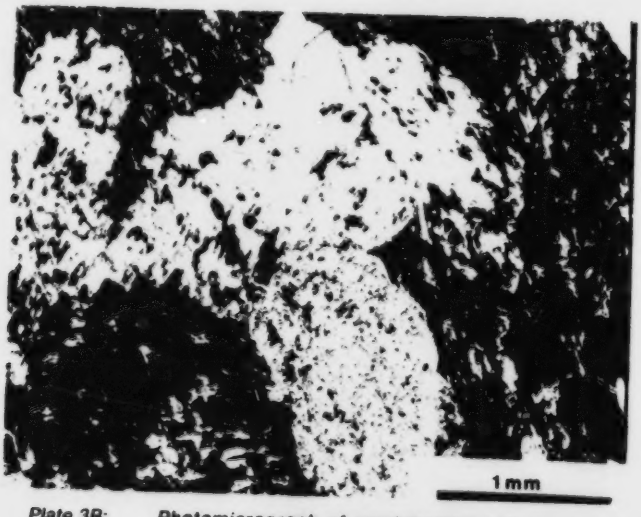


Plate 3B: *Photomicrograph of amphibolitized clinopyroxene cumulate (sample 1-339A, Sandy Bar Narrows, Occurrence #11). Large (1.5 - 2 mm), tightly packed amphibolite pseudomorphs after clinopyroxene exhibit faint "cross hatch" twinning (crossed nicols).*

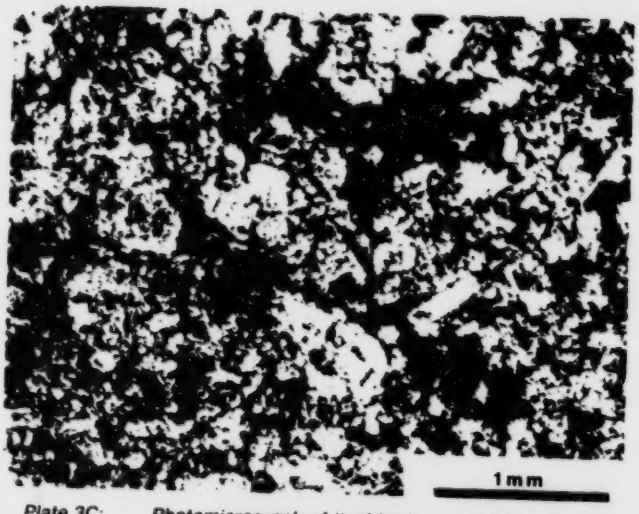


Plate 3C: *Photomicrograph of "gabbro" - most felsic of a continuous differentiated rock series (sample 1-293, Sandy Bar Narrows, Occurrence #11). Uralitized, ragged pyroxene crystals and plagioclase exhibit an ophitic texture (crossed nicols). Note typical chromite clusters.*

Plate 4A: Flow top breccia, ultramafic occurrence #6 (Sagawitchewan Bay).

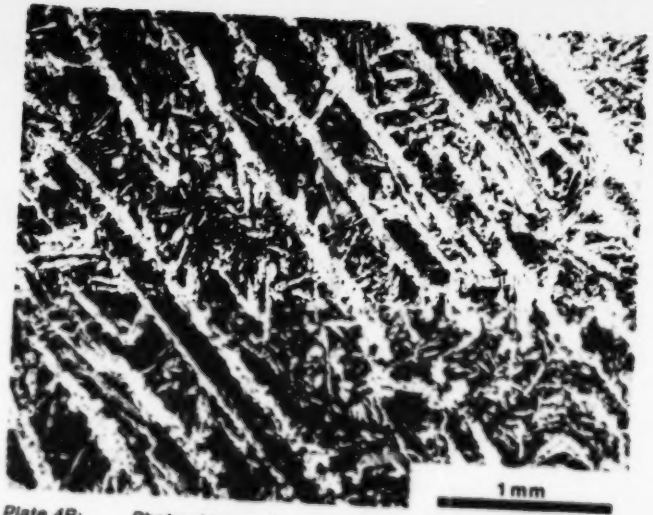


Plate 4B: Photomicrograph of pyroxene spinifex (sample 1-Q, Sagawitchewan Bay, Occurrence #6). Arrays of randomly oriented pyroxene blades interrupted by subparallel carbonate-filled fractures (crossed nicols).

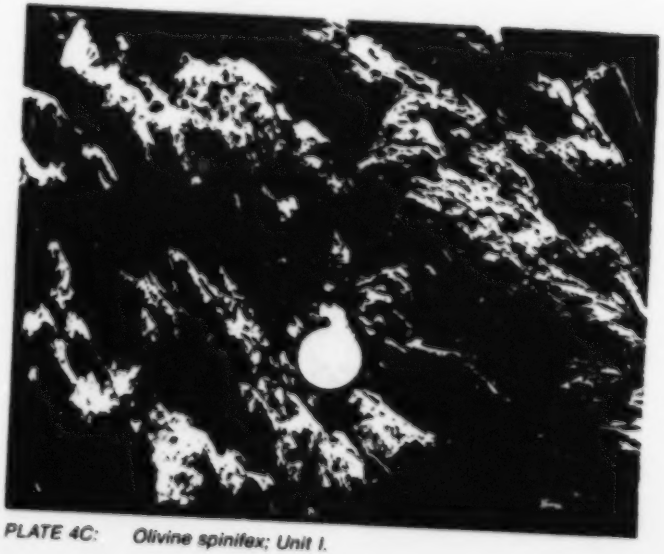

PLATE 4C: Olivine spinifex; Unit I.

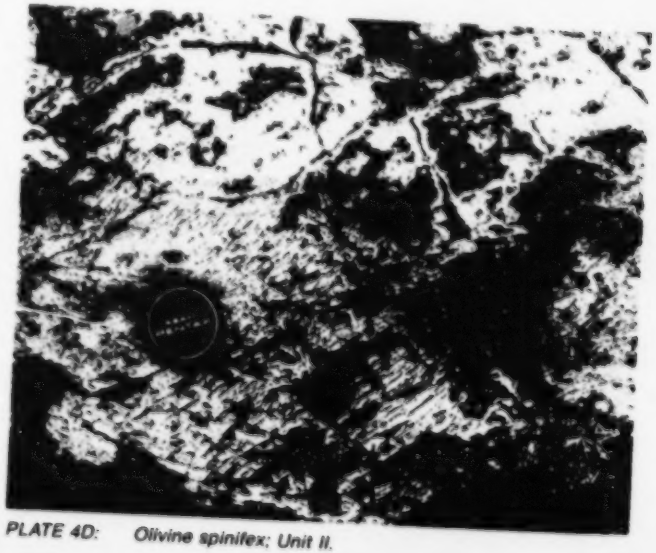

PLATE 4D: Olivine spinifex; Unit II.

## GENETIC MODELS

### DISCUSSION

The following genetic models are presented here in an attempt to explain the occurrence of:

a) extrusive ultramafic rocks associated with an approximately 70 km long sequence of argillite, slate and greywacke that contains several lenses of olivine cumulate;
b) two apparently randomly located lenses of olivine cumulate rock that are outstanding due to their fresh olivine;
c) a thin layer of ultramafic rock considered to be part of a mafic to ultramafic sill.

Rock layers comprising ultramafic occurrences tend to concentrate strain in stressed areas. The strain often disrupts primary rock distributions and the association of ultramafic and adjacent rocks does not necessarily represent their primary distribution; it is probably only an indication that these rocks occupied a common stratigraphic layer before tectonic re-arrangement.

Unit I ultramafic rocks are thought to be genetically related. This argument is based mainly on their stratabound nature evidenced by their recurrent association with sedimentary rocks of a single stratum as well as their petrological and petrochemical resemblance. The occurrence of spinifex textured ultramafic rocks on the northwest and on the southeast end of this stratum is thought to indicate that many - if not all - ultramafic rocks in this rock layer are of extrusive or shallow intrusive origin. It is possible that all ultramafic rocks in the Island Lake area were emplaced in a single event, if Unit I ultramafic rocks are part of an intrusive sill. The spinifex textured ultramafic occurrences could have been derived from small amounts of magma that reached the crustal surface. This model calls for the existence of feeder dykes cross-cutting rocks of the Hayes River Group; such feeder dykes could be represented by the isolated occurrences of ultramafic rocks in rocks of the Hayes River Group ("Trinity Shoals", "south of Linklater Island"). The ultramafic occurrence on Jubilee Island appears to be part of a thin mafic-ultramafic sill that could be an integral part of the Hayes River Group volcanism and would thus be older than the Unit I emplacement event. However, a paucity of data on this occurrence and on the ultramafic rocks on Henderson Island precludes a definitive statement on their origin. Post- emplacement tectonic disruption of the Unit I sill could have resulted in competent gabbroic rocks being separated from the ductile, serpentinized ultramafic rocks; this would account for ultramafic rock lenses observed now in structural contact with a variety of sedimentary, gabbroic and volcanic rocks.

A variation of this model in which all Unit I ultramafic rocks are of extrusive origin cannot be discounted. The rarity of spinifex textures, skeletal olivine, pyroxene, chromite, columnar jointing and pillow structures in the Island Lake ultramafic rocks does not preclude an extrusive origin since these features are not always present in ultramafic volcanic flows (Pyke et al., 1973).

A third model that is considered envisages Unit I ultramafic rocks as genetically unrelated tectonic fragments of intrusive and extrusive rocks. Multiple, genetically unrelated ultramafic fragments are described from other greenstone belts such as from the South African Archean (Viljoen and Viljoen, 1969) as well as from the Archean Abitibi greenstone belt (Pyke, 1976).

All three models infer the existence of an ultramafic liquid that after emplacement produced komatiitic rocks characterized by spinifex textures and a particular chemical signature. Naldrett and Turner (1977) proposed a deep-seated (100 - 250 km) source region for such a liquid. The path of the ascending magma would have been determined by tectonic inhomogeneities such as deep-reaching faults. The level of emplacement of ultramafic magma within the crust, however, would have been determined to some extent by the presence of easily penetrated layers of ductile and incompetent rocks. At shallow depth, these could be invaded and displaced by the ascending ultramafic liquids.

## ECONOMIC GEOLOGY

Ultramafic rocks are at present the main sources of nickel, cobalt and chromium and are also important sources of copper and Platinum Group Metals.

### NICKEL MINERALIZATION

Only certain classes of ultramafic bodies tend to contain nickel sulphide ores. The large, stratiform, layered mafic-ultramafic intrusive complex of Sudbury (Naldrett, 1973) is of considerable economic importance in Canada. In Island Lake, ultramafic bodies are small, stratigraphically controlled lenses and thus only the volcanic associated Fe-Ni-Cu sulphide deposit type may be present here. The Fe-Ni-Cu deposits associated with ultramafic volcanic rocks (Groves et al., 1976) are of considerable economic importance in Australia (Kambalda, Windarra, Scotia); however, they are of only secondary importance in Canada (Texmont, Langmuir, Dundonald, etc.). Volcanic associated Fe-Ni-Cu sulphide deposits tend to be small (less than 4 x $10^6$ tons) but are often concentrated in sulphide layers at or close to the stratigraphic base of the ultramafic host.

The high degree of tectonic disruption and the poor stratigraphic control resulting from the paucity of outcrop precludes the strict application of such a model in the Island Lake area. Nickel sulphides may have been modified and remobilized by metamorphism and structural events and thus may not even occur within these ultramafic rock units.

A nickel-copper mineralization of reportedly low grade (Quinn, 1960) is located in sheared peridotite east of Linklater Island where the Canadian Nickel Company undertook at least 12,800 m of diamond drilling between 1956 and 1960. No other details are available at present.

Irregularly distributed chalcopyrite and millerite were noticed by Quinn and Meinert (1959) on an island north of Loonfoot Island (Ultramafic Occurrence #13, Fig. 6). Diamond drilling on this property was reported by Godard (1963a). Cominco restaked the ground in 1970 and undertook geophysical and geological surveys over this ground (Mineral Inventory Card NTS 53E/16, Ref. Ni 1); however, the claims were allowed to lapse in 1979 and 1980.

### PLATINUM GROUP MINERALIZATION

Elements of the platinum group tend to occur in combination with chrome spinel in the dunitic part of zoned ultramafic intrusions, e.g. Nishne Tagil, (Smirnov, 1977) or in combination with sulphides, mainly in the gabbroic portion of large layered mafic-ultramafic sills, e.g. Stillwater Complex, USA (Conn, 1979), and the Bushveld Complex (Cousins, 1969). The potential for metals of the platinum group in Island Lake is considered to be low since ultramafic rocks of this type have not been identified in this area.

### GOLD MINERALIZATION POTENTIAL

The correlation between gold mineralization and ultramafic rocks of komatiitic chemistry was emphasized by Viljoen et al. (1969) for several gold deposits in the Steynsdorp Goldfields of the Barberton Mountain Land (South Africa). On geochemical considerations, they proposed that ultramafic to mafic rocks transported gold from the mantle to the crust. Gold would initially have been concentrated by sedimentary and biological processes and by thermal and dynamic metamorphism. Other geologists have noticed this association in other

Archean greenstone belts such as the Eastern Gold Fields, Western Australia (Travis et al., 1971) and in Canadian greenstone belts, especially those of the Superior Geological Province (Pyke, 1976). The mechanism of this association remains conjectural. Ultramafic rocks could be a primary source of gold which was subsequently liberated from these rocks due to their propensity for alteration. Carbonatization may play an important role in liberating the gold from ultramafic rocks followed by concentration and deposition in a suitable environment. Alternatively, extrusive and shallow intrusive ultramafic rocks were emplaced coincident with an evolutionary stage of a greenstone belt that for some presently unknown reason was favourable for the deposition and concentration of gold.

Hodgson (1981) in his analysis of gold deposits in the Canadian Superior Province concluded that the association of gold deposits with ultramafic and mafic volcanic rocks and sedimentary rocks is statistically of great importance. Pyke (1976) argued that gold in the Timmins camp was released by carbonatization of ultramafic komatiitic rocks since: a) there is a close spatial association between gold deposits and ultramafic rocks; b) there are relatively high gold contents in ultramafic rocks; c) data by Keays (1975) indicate that gold is released from talc-carbonate altered ultramafic rocks; and d) the Timmins camp and other Archean gold camps show the same rock association. More recently Pyke (1980) enlarged on this concept by considering: a) the role of faulting and fracturing in the preparation of the host rock; b) the function of certain sedimentary rocks as sources of $CO_2$.

The Island Lake area appears to be a target of prime importance in the search for gold since:

1) ultramafic rocks of komatiitic chemistry are a potential source rock for the gold;
2) the ultramafic rocks are carbonatized in part. Pervasive carbonatization was noted in the area east of Linklater Island and in one exposure in Sagawitchewan Bay (Occurrence #2, Fig. 8). Extensive carbonatization occurs in the area west of Loonfoot Island (Occurrence #2, Fig. 6);
3) the ultramafic rocks occur in an area characterized by intense shearing, shear folding and faulting;
4) geochemically anomalous concentrations of Au, As and W were found in rock samples collected in grid patterns adjoining the Unit I ultramafic rocks of northwestern Island Lake. The lithogeochemical anomalies of these elements are overlapping and thus highlight areas with enhanced metal content.

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## APPENDIX I

## IMPORTANT GEOLOGICAL FEATURES OF ULTRAMAFIC ROCKS IN THE ISLAND LAKE AREA
## AREA: LINKLATER ISLAND

| Occurence No. | Geological Contacts | Petrography | Remarks |
|---|---|---|---|
| 1 | Faulted; felsic pyroclastic rocks | Tremolite-actinolite schist | Original mineralogy obliterated; may not have been an ultramafic rock. |
| 2 | Faulted; epiclastic sediments | Olivine spinifex, serpentinized olivine cumulate. Carbonatized pyroxene cumulate? | Patchy olivine spinifex in carbonate rock. Olivine cumulate with large embayed chromite approximately 1 m distance from the spinifex. Very carbonatized in part. |
| 3 | Faulted; felsic pyroclastic rocks | Tremolite-actinolite schist | On strike with occurence #1. Same remarks apply. |
| 4 | Unknown | Olivine cumulate | Serpentine pseudomorphs after olivine, little carbonatized groundmass. |
| 5 | Sheared, gabbro | Olivine cumulate, densely packed; minor disseminated chromite | Altered ultramafic rock in abrupt contact with unaltered gabbro. |
| 6 | Sheared; gabbro | Olivine cumulate | As above. |
| 7 | None; surrounded by water | Antigorite after olivine or pyroxene | Original mineralogy unidentifiable. Magnetite dusting suggests olivine shapes. |
| 8 | None; surrounded by water | Dunite, olivine cumulate | Abundant chromite crystals (0.3 - 0.5 mm) may indicate intrusive character |
| 9 | None, surrounded by water. Close to felsic pyroclastic rocks | Dunite, olivine cumulate. Olivine phenocrysts (up to 1 cm) | Large fluctuation in olivine sizes (background 0.5 - 0.8 mm; phenocrysts 1 cm) Minor interstitial chlorite and magnetite dusting. Interpreted as intrusive rock. |
| 10 | Sheared; argillite, chert, wacke | Uralitized and serpentinized pyroxenite, bastite after pyroxene, gabbroic texture | Large pyroxenite intrusion. |
| 11 | Argillite, wacke | Unknown | Drill hole information - INCO Ltd., Man. MRD File #99283 |

## IMPORTANT GEOLOGICAL FEATURES OF ULTRAMAFIC ROCKS IN THE ISLAND LAKE AREA
## AREA: SANDY BAR NARROWS - LOONFOOT ISLAND

| Occurence No. | Geological Contacts | Petrography | Remarks |
|---|---|---|---|
| 1 | Sheared; felsic volcanic rock | Tightly packed equant olivine cumulate, 30% carbonatized, clinopyroxene oikocrysts | Subhedral 0.5 - 1.3 mm chromite crystals regularly distributed and clinopyroxene oikocrysts interpreted as indicative of intrusive rocks. |
| 2 | None; surrounded by water | Hypidiomorphic and equant antigorite pseudomorphs after olivine. Olivine rims. | Postcumulate growth of olivine (rimming). Pyroxene oikocrysts interpreted as intrusive rocks. |
| 3 | Sheared; felsic volcanic rock | Very carbonatized, original mineralogy largely obliterated. Some remnant pyroxene. | |
| 4 | Intensely sheared; felsic rock | Olivine cumulate, pyroxene, interstitial chlorite, 0.3 - 0.5 mm chromite | Dunitic rock with large subhedral olivine 10 mm. 10% interstitial chlorite interpreted as former plagioclase. Embayed chromite crystals. |
| 5 | Sheared; intermediate to felsic volcaniclastic rock | Carbonatized olivine cumulate with pyroxene oikocrysts | Approximately 60 - 70% carbonatized olivine cumulate. |
| 6 | None; surrounded by water | Olivine cumulate associated with pyroxenite | Tectonically disturbed assemblage of olivine cumulate in association with pyroxenite. |
| 7 | Sheared; mafic flows | Olivine cumulate, minor pyroxene | |
| 8 | Sheared; argillite; mafic volcanic rock | Olivine cumulate, pyroxene oikocrysts | Equant to elongated olivine crystal cumulate. Postcumulate pyroxene oikocrysts. Interpreted as intrusive rock. |
| 9 | Sheared; argillite, volcanic fragmental rocks | Cumulate rock, equant olivine, clinopyroxene oikocrysts | Intrusive cumulate rock. Postcumulate pyroxene growth. |
| 10 | Sheared; argillite, carbonatized wacke, felsic volcanic fragmental rocks | Pyroxene cumulate, subordinate interstitial chlorite and serpentinized olivine | Intrusive cumulate rock. Abundant 0.2 - 0.3 mm chromite. |
| 11 | Undistrubed; gabbro, sheared; mafic flows | Olivine cumulate, pyroxene cumulate, pyroxene feldspar cumulate | Layered intrusive differentiated to gabbro, olivine cumulate, and pyroxene cumulate. |
| 12 | Sheared, pillowed mafic flows | Olivine cumulate, pyroxene? cumulate | Extremely carbonatized. Olivine cumulate recognizable. Pyroxene cumulate doubtful. Relationship between both not determined. |
| 13 | None; surrounded by water | Subhedral elongated olivine, interstitial chromite and magnetite | Coarse olivine cumulate antigoritized and pervasively carbonatized, obliterating much of the original mineralogy. |

## IMPORTANT GEOLOGICAL FEATURES OF ULTRAMAFIC ROCKS IN THE ISLAND LAKE AREA
## AREA: STEVENSON ISLAND

| Occurence No. | Geological Contacts | Petrology | Remarks |
|---|---|---|---|
| 1 | None; surrounded by water | Partially preserved olivine | Very similar to dunites south of Linklater Island. |
| 2 | | Antigorite pseudomorphs after olivine. Interstitial chlorite. Pyroxene oikocrysts. | Ultramafic layer of mafic-ultramafic differentiated sill. |
| 3 | Faulted and sheared; gabbro | Olivine cumulate, interstitial pyroxene, minor talc and chlorite. | Disseminated chromite; intrusive appearance. |
| 4 | None; surrounded by water | Densely packed olivine cumulate, interstitial pyroxene | Parallel trains of magnetite. Post-depositional deformation. 50% carbonatized. |
| 5 | Sheared; epiclastic sediments | Amphibolized pyroxene oikocrysts enclosing antigoritized olivine, subordinate chlorite | Olivine clinopyroxenite, differentiated. Ultramafic layer of mafic-ultramafic sill. |
| 6 | Sheared; felsic tuff | Densely packed olivine cumulate. Regularly scattered, idiomorphic 0.3 - 0.5 mm chromite | Altered, carbonatized in veins and patches. Chromite size and distribution indicates intrusive rock. |

## IMPORTANT GEOLOGICAL FEATURES OF ULTRAMAFIC ROCKS IN THE ISLAND LAKE AREA
## AREA: SAGAWITCHEWAN BAY

| Occurrence # | Geological Contacts | Petrography | Remarks |
|---|---|---|---|
| 1 | None; surrounded by water | Olivine cumulate | Carbonatized antigorite pseudomorphs after olivine. |
| 2 | None; surrounded by water. Separated from black argillites by 30 m water. | Olivine cumulate | Southeastern third of island completely carbonatized. Original mineralogy replaced by carbonate-talc rock. |
| 3 | None; surrounded by water | Olivine cumulate, minor clinopyroxene. | Densely packed antigoritized olivine cumulate. |
| 4 | None; surrounded by water. | Olivine cumulate | Antigoritized olivine cumulate. Penetrative carbonate alteration in patches and veins. Minor talc alteration. |
| 5 | None; surrounded by water. | Olivine cumulate | Antigoritized olivine cumulate. Carbonatized in penetrative veins and patches. Talc alteration present. |
| 6 | None, surrounded by water; within 100 m of island with epiclastic sediments and gabbro. | Pyroxene spinifex. Olivine spinifex. Olivine cumulate. | Underlain by at least two separate flows. Pyroxene spinifex, olivine spinifex, olivine cumulate and flow top rubble can be distinguished. Type of association unknown. Interpreted as discrete separate pulses of extrusive magma. |

## IMPORTANT GEOLOGICAL FEATURES OF ULTRAMAFIC ROCKS IN THE ISLAND LAKE AREA
## AREA: HENDERSON ISLAND

| Occurrence # | Geological Contacts | Petrography | Results |
|---|---|---|---|
| 1 | Sheared and faulted; felsic fragmental rocks, amphibolites | Extremely fine grained serpentine, carbonate | Original rock unidentifiable. Phacoidal aggregate of serpentine flakes; pyroxene fragments and carbonate. Phacoids with concentric oolitic structures may reach up to 1 cm diameter. |

## APPENDIX II
## CHEMICAL COMPOSITION OF ULTRAMAFIC ROCKS - ISLAND LAKE

### a) RAW DATA (46 Samples)

| | 51-7-96 | 51-7-97 | 51-7-99 | 51-7-104 | 51-7-113 | 51-7-129 | 51-8-0-5 | 51-0-5A | 51-0-26 | 51-0-30 | 51-0-33 | 51-1-203 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 30.00 | 38.20 | 38.30 | 38.55 | 40.45 | 35.25 | 38.95 | 36.65 | 36.90 | 37.55 | 38.45 | 38.25 |
| $Al_2O_3$ | 1.80 | 4.57 | 4.05 | 1.43 | 6.62 | 1.87 | 3.68 | 0.89 | 0.84 | 2.63 | 1.35 | 2.85 |
| $Fe_2O_3$ | 1.46 | 4.63 | 3.15 | 5.91 | 0.67 | 12.65 | 3.92 | 8.54 | 4.50 | 7.98 | 5.73 | 5.58 |
| FeO | 6.16 | 5.33 | 6.64 | 2.84 | 9.42 | 3.00 | 4.70 | 1.87 | 1.65 | 4.49 | 1.55 | 5.13 |
| CaO | 0.13 | 4.19 | 3.64 | 1.46 | 15.23 | 0.28 | 5.29 | 0.01 | 3.46 | 0.19 | 0.54 | 6.82 |
| MgO | 33.3 | 27.7 | 27.1 | 36.1 | 16.74 | 34.7 | 27.2 | 37.2 | 36.4 | 34.8 | 38.4 | 25.4 |
| $Na_2O$ | 0.06 | — | — | 0.06 | 0.10 | — | 0.02 | 0.01 | — | 0.02 | 0.03 | — |
| $K_2O$ | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.04 | 0.03 | 0.02 |
| $TiO_2$ | 0.11 | 0.26 | 0.17 | 0.04 | 0.32 | 0.03 | 0.24 | 0.03 | 0.03 | 0.09 | 0.04 | 0.13 |
| $P_2O_5$ | 0.03 | 0.04 | 0.03 | 0.04 | 0.05 | 0.03 | 0.08 | 0.06 | 0.02 | 0.03 | 0.02 | 0.04 |
| MnO | 0.18 | 0.12 | 0.12 | 0.11 | 0.22 | 0.13 | 0.15 | 0.13 | 0.08 | 0.10 | 0.09 | 0.08 |
| NiO | 0.28 | 0.21 | 0.20 | 0.27 | 0.17 | 0.27 | — | 0.27 | 0.25 | 0.23 | 0.29 | 0.49 |
| $Cr_2O_3$ | 0.11 | 0.17 | 0.35 | 0.31 | 0.20 | 0.39 | — | 0.36 | 0.16 | 0.34 | 0.11 | 0.34 |
| $H_2O$ | 3.48 | 5.98 | 5.66 | 10.8 | 4.45 | 10.8 | 5.53 | 10.5 | 10.8 | 11.3 | 12.4 | 4.37 |
| S | 0.17 | 0.07 | 0.09 | 0.02 | — | TR. | 0.11 | — | TR. | 0.03 | 0.02 | 0.26 |
| $CO_2$ | 21.3 | 8.12 | 9.71 | 2.35 | 5.85 | 0.60 | 9.87 | 3.19 | 4.65 | 0.34 | 1.28 | 9.99 |
| CuO | — | — | — | — | — | — | — | — | — | — | — | — |
| Others | 0.53 | 0.58 | 0.91 | 0.91 | 0.60 | 1.05 | | 0.98 | 0.58 | 0.00 | 0.53 | 1.19 |
| TOTAL | 98.95 | 99.79 | 99.56 | 100.64 | 100.25 | 100.52 | 99.73 | 100.09 | 99.93 | 100.49 | 100.45 | 100.01 |
| Cu | 27 | 57 | 38 | 32 | 16 | 2 | — | 3 | 8 | 3 | 3 | 172 |
| Ni | 2270 | 1670 | 1600 | 2200 | 1350 | 2180 | — | 2160 | 2040 | 1880 | 2340 | 3880 |
| Pb | 3 | 3 | 3 | 3 | 3 | 3 | — | 3 | 3 | 3 | 3 | 3 |
| Zn | 43 | 33 | 54 | 30 | 180 | 36 | — | 33 | 18 | 25 | 33 | 45 |
| Cr | 1550 | 2325 | 4700 | 4200 | 2700 | 5250 | — | 4750 | 2125 | 4500 | 1575 | 4500 |
| Rb | 2 | 2 | 2 | 2 | 2 | 2 | — | 2 | 2 | 2 | 2 | 2 |
| Sr | 5 | 50 | 10 | 10 | 60 | 10 | — | 5 | 25 | 5 | 5 | 50 |
| Ba | 40 | 50 | 30 | 20 | 30 | 10 | — | 20 | 30 | 30 | 10 | 30 |

## CHEMICAL COMPOSITION OF ULTRAMAFIC ROCKS - ISLAND LAKE

### RAW DATA

| | 51-1-207 | 51-1-213 | 51-1-214 | 51-1-217 | 51-1-219 | 51-1-220 | 51-1-221 | 51-1-226 | 51-1-259 | 51-1-261 | 51-1-268 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 38.40 | 37.00 | 35.05 | 38.60 | 47.65 | 47.60 | 52.50 | 30.00 | 33.65 | 45.85 | 40.80 |
| $Al_2O_3$ | 1.86 | 1.78 | 0.93 | 2.35 | 5.01 | 4.15 | 4.66 | 1.06 | 2.30 | 2.34 | 2.48 |
| $Fe_2O_3$ | 3.76 | 6.57 | 8.91 | 7.08 | 2.05 | 0.97 | 0.92 | 6.71 | 6.39 | 5.28 | 4.74 |
| FeO | 4.80 | 2.78 | 1.70 | 3.57 | 7.63 | 5.52 | 7.57 | 1.98 | 2.72 | 4.31 | 2.42 |
| CaO | 2.07 | 0.12 | 2.81 | 0.50 | 3.47 | 11.69 | 12.58 | 0.22 | 5.68 | 0.30 | 1.07 |
| MgO | 32.7 | 36.6 | 35.6 | 34.5 | 25.1 | 22.40 | 17.79 | 34.6 | 32.7 | 32.0 | 35.7 |
| $Na_2O$ | 0.01 | 0.04 | 0.03 | — | 0.01 | 0.09 | 0.74 | — | 0.02 | 0.02 | — |
| $K_2O$ | 0.02 | 0.03 | 0.01 | 0.02 | 0.02 | 0.04 | 0.04 | — | 0.05 | 0.03 | 0.01 |
| $TiO_2$ | 0.08 | 0.07 | 0.01 | 0.05 | 0.29 | 0.24 | 0.28 | 0.02 | 0.08 | 0.11 | 0.06 |
| $P_2O_5$ | 0.03 | 0.04 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.04 | 0.03 | 0.04 | 0.02 |
| MnO | 0.08 | 0.11 | 0.11 | 0.05 | 0.09 | 0.14 | 0.17 | 0.09 | 0.13 | 0.06 | 0.07 |
| NiO | 0.86 | 0.26 | 0.26 | 0.23 | 0.13 | 0.03 | 0.03 | 0.18 | 0.24 | 0.24 | 0.25 |
| $Cr_2O_3$ | 0 12 | 0.33 | 0.38 | 0.34 | 0.32 | 0.28 | 0.05 | 0.35 | 0.37 | 0.32 | 0.31 |
| $H_2O$ | 8.22 | 10.6 | 10.0 | 10.1 | 6.33 | 4.97 | 3.01 | 2.88 | 10.62 | 8.49 | 10.59 |
| S | 0.88 | TR. | — | 0.01 | — | — | — | — | — | 0.02 | 0.02 |
| $CO_2$ | 5.89 | 3.09 | 4.37 | 2.42 | 1.35 | 2.39 | 0.77 | 21.3 | 4.36 | 0.92 | 1.52 |
| CuO | 0.06 | — | — | — | — | — | — | — | — | — | — |
| Others | 1.18 | 0.93 | 1.02 | 0.90 | 0.77 | 0.59 | 0.77 | 0.87 | 0.99 | 0.89 | 0.89 |
| TOTAL | 100.04 | 99.76 | 100.59 | 100.19 | 99.82 | 100.84 | 100.74 | 99.77 | 99.72 | 100.66 | 100.38 |
| Cu | 520 | 13 | 2 | 2 | 50 | 3 | 34 | 1 | 3 | 53 | 14 |
| Ni | 6800 | 2110 | 2110 | 1810 | 1040 | 263 | 243 | 1470 | 1950 | 1950 | 2050 |
| Pb | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Zn | 38 | 24 | 27 | 23 | 36 | 44 | 46 | 22 | 43 | 56 | 39 |
| Cr | 1650 | 4450 | 5100 | 4500 | 4250 | 3700 | 760 | 4650 | 4950 | 4250 | 4200 |
| Rb | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Sr | 15 | 5 | 25 | 10 | 10 | 10 | 10 | 5 | 45 | 5 | 5 |
| Ba | 40 | 30 | 20 | 40 | 20 | 60 | 60 | 20 | 40 | 40 | 30 |

## CHEMICAL COMPOSITION OF ULTRAMAFIC ROCKS - ISLAND LAKE

### RAW DATA

| | 51-1-268 | 51-1-274 | 51-1-276 | 51-1-279 | 51-1-289 | 51-1-290 | 51-1-291 | 51-1-292 | 51-1-313 | 51-1-314 | 51-1-315 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 32.70 | 40.25 | 39.40 | 40.90 | 37.40 | 39.40 | 42.05 | 43.53 | 37.55 | 37.90 | 37.00 |
| $Al_2O_3$ | 8.51 | 3.47 | 3.63 | 2.50 | 3.28 | 3.22 | 5.68 | 5.52 | 1.92 | 2.77 | 1.60 |
| $Fe_2O_3$ | 3.98 | 4.17 | 3.63 | 3.51 | 6.03 | 5.15 | 6.30 | 2.95 | 4.18 | 10.02 | 4.34 |
| FeO | 2.50 | 1.36 | 5.97 | 6.31 | 3.16 | 1.90 | 7.89 | 4.77 | 3.59 | 5.87 | 5.43 |
| CaO | 2.05 | 2.78 | 4.99 | 3.92 | 1.66 | 1.95 | 6.99 | 7.68 | 0.56 | 0.21 | 0.53 |
| MgO | 34.6 | 35.5 | 29.45 | 29.12 | 34.6 | 35.4 | 23.23 | 26.26 | 36.8 | 32.6 | 35.4 |
| $Na_2O$ | 0.02 | 0.04 | 0.03 | — | 0.03 | 0.01 | 0.20 | 0.04 | — | — | 0.01 |
| $K_2O$ | 0.04 | 0.06 | 0.02 | 0.01 | 0.02 | 0.03 | 0.03 | 0.05 | — | — | 0.02 |
| $TiO_2$ | 0.93 | 0.12 | 0.18 | 0.09 | 0.14 | 0.11 | 0.23 | 0.43 | 0.04 | 0.11 | 0.06 |
| $P_2O_5$ | 0.11 | 0.02 | 0.03 | 0.03 | 0.03 | 0.02 | 0.05 | 0.06 | 0.03 | 0.04 | 0.03 |
| MnO | 0.51 | 0.15 | 0.11 | 0.09 | 0.13 | 0.12 | 0.17 | 0.16 | 0.07 | 0.10 | 0.12 |
| NiO | 0.13 | 0.27 | 0.23 | 0.23 | 0.24 | 0.28 | 0.14 | 0.19 | 0.28 | 0.24 | 0.26 |
| $Cr_2O_3$ | 0.01 | 0.32 | 0.31 | 0.34 | 0.35 | 0.31 | 0.19 | 0.30 | 0.31 | 0.27 | 0.33 |
| $H_2O$ | 11.44 | 11.25 | 10.06 | 9.30 | 11.76 | 11.44 | 6.39 | 7.38 | 11.01 | 9.86 | 9.94 |
| S | 0.02 | 0.04 | 0.23 | 0.49 | — | 0.04 | 0.05 | 0.04 | 0.01 | 0.04 | 0.08 |
| $CO_2$ | 2.59 | 0.15 | 1.57 | 3.01 | 1.26 | 0.15 | 0.10 | 1.28 | 3.73 | 0.37 | 4.38 |
| CuO | — | — | — | — | — | — | — | — | — | — | — |
| Others | 0.17 | 0.91 | 0.87 | 0.91 | 0.95 | 0.90 | 0.53 | 0.80 | 0.90 | 0.78 | 0.93 |
| TOTAL | 100.16 | 100.25 | 100.17 | 99.99 | 100.45 | 99.82 | 99.87 | 100.77 | 100.39 | 100.66 | 99.84 |
| Cu | 4 | 6 | 152 | 36 | 15 | 22 | 28 | 25 | 3 | 13 | 17 |
| Ni | 1060 | 2160 | 1870 | 1840 | 1960 | 2230 | 1120 | 1500 | 2250 | 1960 | 2090 |
| Pb | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Zn | 69 | 45 | 53 | 48 | 54 | 37 | 71 | 65 | 38 | 36 | 33 |
| Cr | 176 | 4250 | 4150 | 4550 | 4700 | 4150 | 2250 | 4050 | 4140 | 3600 | 4450 |
| Rb | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 4 | 2 | 2 | 2 |
| Sr | 5 | 5 | 5 | 10 | 5 | 5 | 5 | 10 | 5 | 5 | 5 |
| Ba | 30 | 20 | 10 | 10 | 40 | 10 | 30 | 60 | 50 | 20 | 40 |

## CHEMICAL COMPOSITION OF ULTRAMAFIC ROCKS - ISLAND LAKE

### RAW DATA

| | 51-1-323 | 51-1-324 | 51-1-325 | 51-1-329 | 51-1-333 | 51-1-334 | 51-1-340 | 51-1-350 | 51-1-352 | 51-1-353 | 51-1-358 | 51-1-363 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 37.35 | 35.45 | 39.15 | 39.15 | 39.45 | 39.65 | 39.35 | 39.60 | 32.65 | 40.45 | 35.75 | 36.55 |
| $Al_2O_3$ | 2.39 | 2.61 | 2.98 | 2.34 | 2.00 | 3.39 | 4.55 | 3.20 | 3.39 | 3.03 | 1.63 | 3.03 |
| $Fe_2O_3$ | 1.63 | 5.58 | 1.91 | 5.76 | 4.13 | 3.89 | 4.66 | 6.65 | 5.81 | 7.72 | 6.53 | 9.61 |
| FeO | 5.52 | 5.07 | 7.09 | 4.87 | 4.23 | 5.21 | 5.31 | 4.47 | 3.41 | 3.63 | 2.20 | 4.47 |
| CaO | 0.63 | 0.47 | 0.20 | 0.06 | 0.07 | 1.58 | 5.36 | 3.02 | 6.78 | 0.65 | 0.14 | 1.35 |
| MgO | 32.3 | 33.7 | 33.2 | 35.2 | 36.4 | 32.7 | 28.2 | 32.5 | 29.6 | 33.6 | 33.3 | 32.2 |
| $Na_2O$ | — | 0.02 | — | — | — | — | 0.02 | 0.02 | 0.01 | — | — | — |
| $K_2O$ | 0.02 | 0.02 | 0.03 | 0.03 | 0.02 | 0.02 | 0.02 | 0.03 | 0.04 | 0.02 | 0.02 | 0.04 |
| $TiO_2$ | 0.13 | 0.11 | 0.09 | 0.07 | 0.10 | 0.17 | 0.21 | 0.16 | 0.14 | 0.11 | 0.07 | 0.17 |
| $P_2O_5$ | 0.04 | 0.04 | 0.03 | 0.03 | 0.03 | 0.04 | 0.04 | 0.05 | 0.05 | 0.05 | 0.05 | 0.06 |
| MnO | 0.07 | 0.18 | 0.10 | 0.04 | 0.10 | 0.11 | 0.13 | 0.13 | 0.19 | 0.08 | 0.08 | 0.14 |
| NiO | 0.26 | 0.25 | 0.17 | 0.27 | 0.25 | 0.24 | 0.20 | 0.22 | 0.20 | 0.25 | 0.25 | 0.67 |
| $Cr_2O_3$ | 0.12 | 0.32 | 0.43 | 0.30 | 0.36 | 0.31 | 0.28 | 0.22 | 0.23 | 0.29 | 0.38 | 0.21 |
| $H_2O$ | 4.33 | 9.15 | 9.64 | 10.94 | 11.0 | 9.81 | 9.06 | 10.2 | 7.64 | 9.95 | 3.65 | 10.5 |
| S | 0.08 | 0.05 | 0.07 | 0.05 | 0.05 | 0.07 | 0.05 | 0.03 | 0.05 | 0.02 | TR. | 1.00 |
| $CO_2$ | 14.7 | 6.12 | 3.60 | 1.19 | 1.48 | 2.35 | 2.89 | 0.34 | 9.79 | 0.74 | 15.3 | 1.14 |
| CuO | — | — | — | — | — | — | — | — | — | — | — | — |
| Others | 0.35 | 0.89 | 1.02 | 0.87 | 0.98 | 0.87 | 0.78 | 0.70 | 0.68 | 0.84 | 1.01 | 1.12 |
| TOTAL | 99.69 | 99.44 | 99.09 | 100.18 | 100.02 | 99.83 | 100.61 | 101.09 | 100.21 | 100.88 | 99.73 | 100.98 |
| Cu | 24 | 5 | 15 | 3 | 59 | 24 | 6 | 195 | 4 | 10 | 4 | 153 |
| Ni | 2080 | 2040 | 1380 | 2140 | 1990 | 1960 | 1600 | 1780 | 1620 | 2040 | 2030 | 5300 |
| Pb | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Zn | 46 | 48 | 62 | 41 | 45 | 41 | 75 | 6 | 60 | 71 | 33 | 65 |
| Cr | 1700 | 4250 | 5700 | 4000 | 4850 | 4150 | 3800 | 2950 | 3150 | 3850 | 5100 | 2850 |
| Rb | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| Sr | 10 | 10 | 5 | 5 | 5 | 10 | 15 | 10 | 20 | 10 | 5 | 5 |
| Ba | 40 | 30 | 20 | 50 | 40 | 40 | 40 | 40 | 40 | 40 | 40 | 40 |

## CHEMICAL COMPOSITION OF ULTRAMAFIC ROCKS - ISLAND LAKE

### b) NORMALIZED DATA

| | 51-7-96 | 51-7-97 | 51-7-99 | 51-7-113 | 51-7-129 | 51-0-5A | 51-0-26 | 51-0-30 | 51-0-33 | 51-0-203 | 51-1-207 | 51-1-213 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 40.62 | 44.68 | 45.70 | 45.04 | 39.66 | 42.52 | 43.70 | 42.39 | 44.31 | 44.78 | 45.41 | 43.09 |
| $Al_2O_3$ | 2.47 | 5.34 | 4.83 | 7.37 | 2.10 | 1.03 | 0.99 | 2.96 | 1.55 | 3.33 | 2.19 | 2.07 |
| $Fe_2O_3$ | 1.97 | 5.41 | 3.75 | 0.74 | 14.23 | 9.90 | 5.32 | 9.00 | 6.60 | 6.84 | 4.44 | 7.65 |
| FeO | 8.70 | 6.53 | 8.18 | 10.77 | 3.83 | 2.63 | 2.39 | 5.42 | 2.26 | 6.59 | 6.41 | 3.69 |
| CaO | 0.41 | 4.90 | 4.34 | 16.95 | 0.42 | 0.01 | 4.09 | 0.21 | 0.62 | 7.98 | 2.44 | 0.13 |
| MgO | 45.09 | 32.40 | 32.33 | 18.08 | 39.04 | 43.16 | 43.11 | 39.28 | 44.26 | 29.73 | 38.67 | 42.62 |
| $Na_2O$ | 0.08 | — | — | 0.11 | — | 0.01 | — | 0.02 | 0.03 | — | 0.01 | 0.04 |
| $K_2O$ | 0.04 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.02 | 0.04 | 0.03 | 0.02 | 0.02 | 0.03 |
| $TiO_2$ | 0.14 | 0.35 | 0.20 | 0.35 | 0.03 | 0.03 | 0.03 | 0.10 | 0.04 | 0.15 | 0.09 | 0.08 |
| $P_2O_5$ | 0.04 | 0.30 | 0.03 | 0.05 | 0.03 | 0.06 | 0.02 | 0.03 | 0.02 | 0.04 | 0.03 | 0.04 |
| MnO | 0.24 | 0.04 | 0.14 | 0.24 | 0.14 | 0.15 | 0.09 | 0.11 | 0.10 | 0.15 | 0.09 | 0.12 |

| | 51-1-214 | 51-1-217 | 51-1-222 | 51-1-226 | 51-1-266 | 51-1-268 | 51-1-274 | 51-1-276 | 51-1-279 | 51-1-289 | 51-1-290 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 40.75 | 44.14 | 43.38 | 39.81 | 32.93 | 37.96 | 45.42 | 44.82 | 47.15 | 42.89 | 44.77 |
| $Al_2O_3$ | 1.08 | 2.68 | 3.36 | 1.40 | 1.36 | 9.87 | 3.91 | 4.13 | 2.88 | 3.76 | 3.65 |
| $Fe_2O_3$ | 10.35 | 8.09 | 5.26 | 8.90 | 5.52 | 4.62 | 4.70 | 4.13 | 4.04 | 6.91 | 5.85 |
| FeO | 2.46 | 4.46 | 5.72 | 2.98 | 2.32 | 3.10 | 1.95 | 6.95 | 7.17 | 4.03 | 2.59 |
| CaO | 3.26 | 0.57 | 4.57 | 0.29 | 0.25 | 2.37 | 3.13 | 5.67 | 4.51 | 1.90 | 2.21 |
| MgO | 41.39 | 39.45 | 37.05 | 45.92 | 56.98 | 40.16 | 40.06 | 33.50 | 33.57 | 39.68 | 40.22 |
| $Na_2O$ | 0.03 | — | — | — | — | 0.02 | 0.04 | 0.03 | — | 0.03 | 0.01 |
| $K_2O$ | 0.01 | 0.02 | 0.03 | — | — | 0.04 | 0.06 | 0.02 | 0.01 | 0.02 | 0.03 |
| $TiO_2$ | 0.01 | 0.05 | 0.17 | 0.02 | 0.01 | 1.07 | 0.13 | 0.20 | 0.10 | 0.16 | 0.12 |
| $P_2O_5$ | 0.04 | 0.04 | 0.04 | 0.05 | 0.03 | 0.12 | 0.02 | 0.03 | 0.03 | 0.03 | 0.02 |
| MnO | 0.12 | 0.04 | 0.14 | 0.11 | 0.08 | 0.59 | 0.16 | 0.12 | 0.10 | 0.14 | 0.13 |

| | 51-1-313 | 51-1-314 | 51-1-315 | 51-1-324 | 51-1-325 | 51-1-329 | 51-1-333 | 51-1-340 | 51-1-350 | 51-1-352 | 51-1-353 | 51-1-363 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $SiO_2$ | 43.93 | 42.01 | 43.43 | 42.25 | 45.83 | 44.63 | 45.23 | 44.48 | 43.82 | 39.54 | 44.95 | 41.55 |
| $Al_2O_3$ | 2.24 | 3.07 | 1.87 | 3.11 | 3.48 | 2.66 | 2.29 | 5.14 | 3.54 | 4.10 | 3.36 | 3.44 |
| $Fe_2O_3$ | 4.89 | 11.10 | 5.09 | 6.65 | 2.23 | 5.99 | 4.73 | 5.26 | 7.36 | 7.03 | 8.57 | 10.92 |
| FeO | 4.68 | 6.86 | 6.74 | 6.43 | 8.52 | 5.96 | 5.22 | 6.29 | 5.28 | 4.44 | 4.43 | 5.22 |
| CaO | 0.65 | 0.23 | 0.62 | 0.53 | 0.23 | 0.06 | 0.08 | 6.05 | 3.34 | 8.21 | 0.72 | 1.53 |
| MgO | 43.06 | 36.13 | 41.55 | 40.16 | 38.86 | 40.13 | 41.73 | 31.87 | 35.97 | 35.85 | 37.33 | 36.60 |
| $Na_2O$ | — | — | 0.01 | 0.02 | 0.01 | — | — | 0.02 | 0.02 | 0.01 | — | — |
| $K_2O$ | — | — | 0.02 | 0.02 | 0.03 | 0.03 | 0.02 | 0.02 | 0.03 | 0.04 | 0.02 | 0.04 |
| $TiO_2$ | 0.04 | 0.12 | 0.07 | 0.13 | 0.10 | 0.07 | 0.11 | 0.32 | 0.17 | 0.16 | 0.12 | 0.19 |
| $P_2O_5$ | 0.03 | 0.04 | 0.03 | 0.04 | 0.03 | 0.03 | 0.03 | 0.04 | 0.05 | 0.06 | 0.05 | 0.06 |
| MnO | 0.08 | 0.11 | 0.14 | 0.21 | 0.11 | 0.04 | 0.11 | 0.14 | 0.14 | 0.23 | 0.08 | 0.15 |

94°50'

94°45'

LINKLATER ISLAND

53°55'

53°55'

9
1-214
0-5A
7-95
85
2-477
1-215
1-126
2-478
10
8
7-123
7-124
85
7
1-213
1-213A
5
6
7-120
2
1-207
3
1-208
7-128
7-126
4
1-217
1-217A
C
7-96
7-97
7-323
7-175
1
88
85
70
76
68
2-401
2-402
Fleet Point
11
D2-346-2
12
7-129
7-99
13

LINKLATER ISLAND

Fig. 4

FLEET POINT

"TRINITY SHOALS"

JUBILEE ISLAND

Fig. 5

HEND

53°45'

Manitoba
Energy and Mines

LINKLATER ISLAND
94°30'
94°00'
LOCATION
MANITO
WINNIPEG
N
SCALE
0 5 10
KILOMETRES
Fig. 4
COCHRANE BAY
GARDEN HILL INDIAN RESERVE
FLEET POINT
"TRINITY SHOALS"
STEVENSON ISLAND (AIRPORT)
MEGEESI BAY
JUBILEE ISLAND
Fig. 5
ISLAND
Fig. 10
HENDERSON ISLAND
SAVAGE ISLANDS
LAKE
LOONFOOT I.
Fig. 6
SANDY BAR NARROWS
SAGAWITCHEWAN BAY
Fig. 8
3°45'
94°30'
94°00'

94°30'

94°00'

N

SCALE

0 5 10

KILOMETRES

I RESERVE

LOCATION MAP

ISLAND

Fig. 10

LAKE

SAVAGE ISLANDS

LOONFOOT I.

SANDY BAR NARROWS

Fig. 6

SAGAWITCHEWAN R.

53°45'

SAGAWITCHEWAN BAY

Fig. 8

MANITOBA
ONTARIO

°30'

94°00'

Figure 3

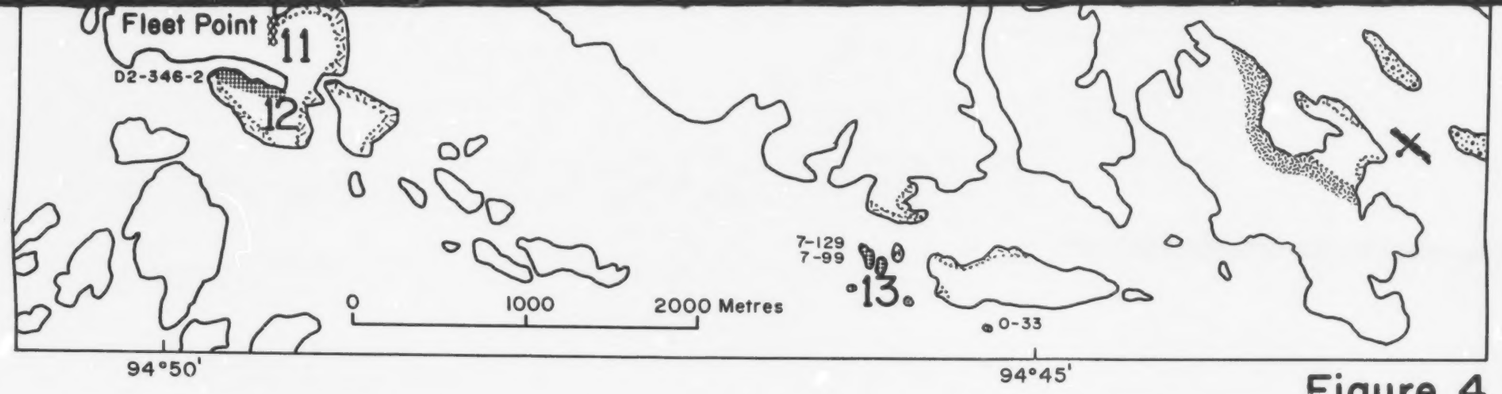
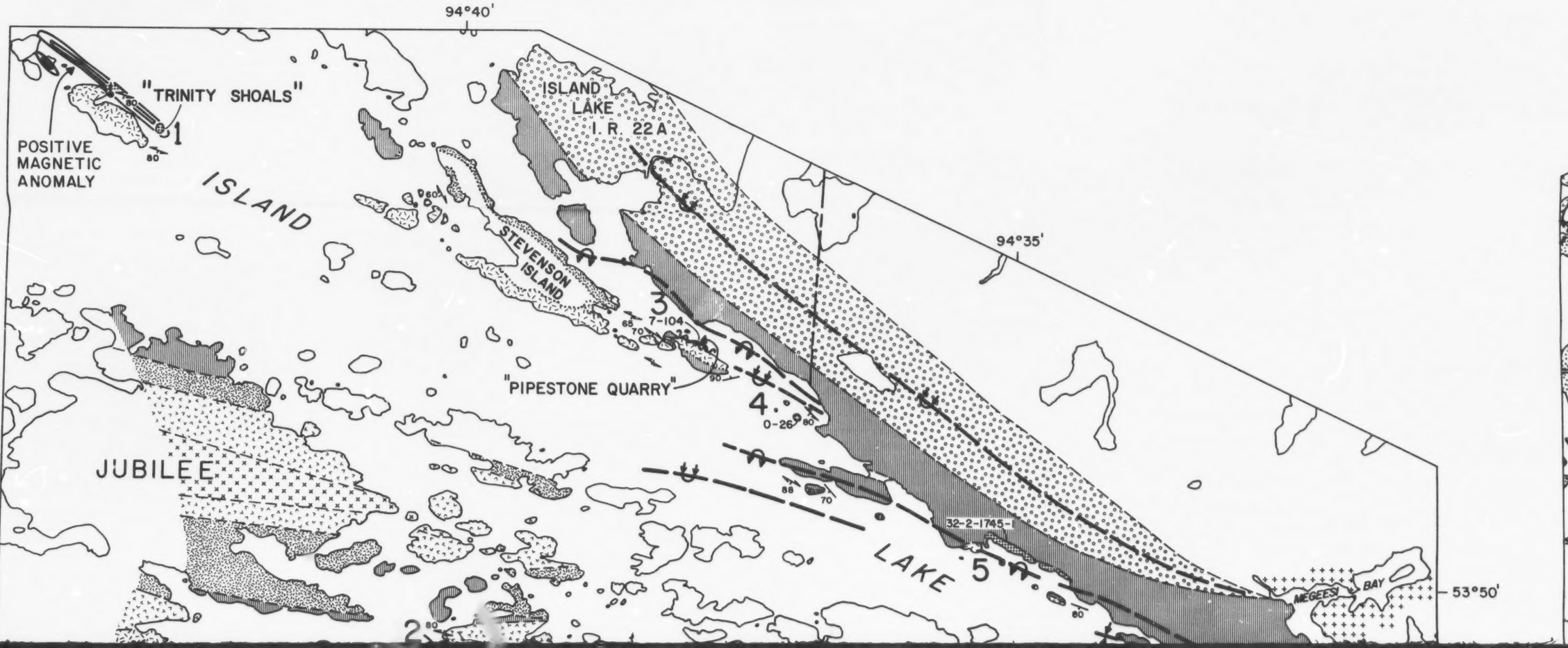

Fleet Point
11
D2-346-2
12
7-129
7-99
13
0-33
0
1000
2000 Metres
94°50'
94°45'

Figure 4


94°40'
"TRINITY SHOALS"
POSITIVE MAGNETIC ANOMALY
1
ISLAND
ISLAND LAKE I. R. 22 A
STEVENSON ISLAND
3
7-104
"PIPESTONE QUARRY"
4
0-26
94°35'
JUBILEE
32-2-1745-I
LAKE
5
MEGEES BAY
53°50'
53°50'
2

SAGAWITCHEWAN BAY

94°30'

94°00'

POSITIVE MAGNETIC ANOMALY

94°05'

53°50'

53°50'

7-108
7-109
7-110
I-363
I-364

I-226
hem + mag

I-358

I-356
I-357
I-364

LOONFOOT ISLAND

0 1000 m

MEGEEKI BAY

53°50'

94°00'

## LEGE

- Late plutonic rocks (quartz d
- Late sedimentary rocks (congl
- Felsic volcanic and associate breccia)
- Mafic intrusive rocks (gabbro
- Olivine cumulate
- Olivine pyroxene cumulate
- Peridotite
- Pyroxenite
- ★ *Peridotitic and pyroxenitic*
- Talc schist
- Severely deformed ultramafic
- Early plutonic rocks (tonalite
- Conglomerate (Garden Hill cong
- Epiclastic and chemical sedime siltstone, feldspathic wacke
- Mafic to intermediate volcani

SAGAWITCHEWAN BAY

94°30'

94°00'

Fig. 8

MANITOBA
ONTARIO

Figure 3

POSITIVE MAGNETIC ANOMALY

94°05'

53°50'

80

108
109
110

ONFOOT
SLAND

0 1000 m

## LEGEND

- Late plutonic rocks (quartz diorite, quartz-feldspar porphyry)
- Late sedimentary rocks (conglomerate, sandstone, minor argillite)
- Felsic volcanic and associated intrusive rocks (flows, tuffs, breccia)
- Mafic intrusive rocks (gabbro, hornblendite)
- Olivine cumulate
- Olivine pyroxene cumulate
- Peridotite
- Pyroxenite
- ★ Peridotitic and pyroxenitic spinifex-textured rocks
- Talc schist
- Severely deformed ultramafic rocks
- Early plutonic rocks (tonalite)
- Conglomerate (Garden Hill conglomerate)
- Epiclastic and chemical sedimentary rocks (argillite, chert, siltstone, feldspathic wacke, iron formation)
- Mafic to intermediate volcanic and related intrusive rocks

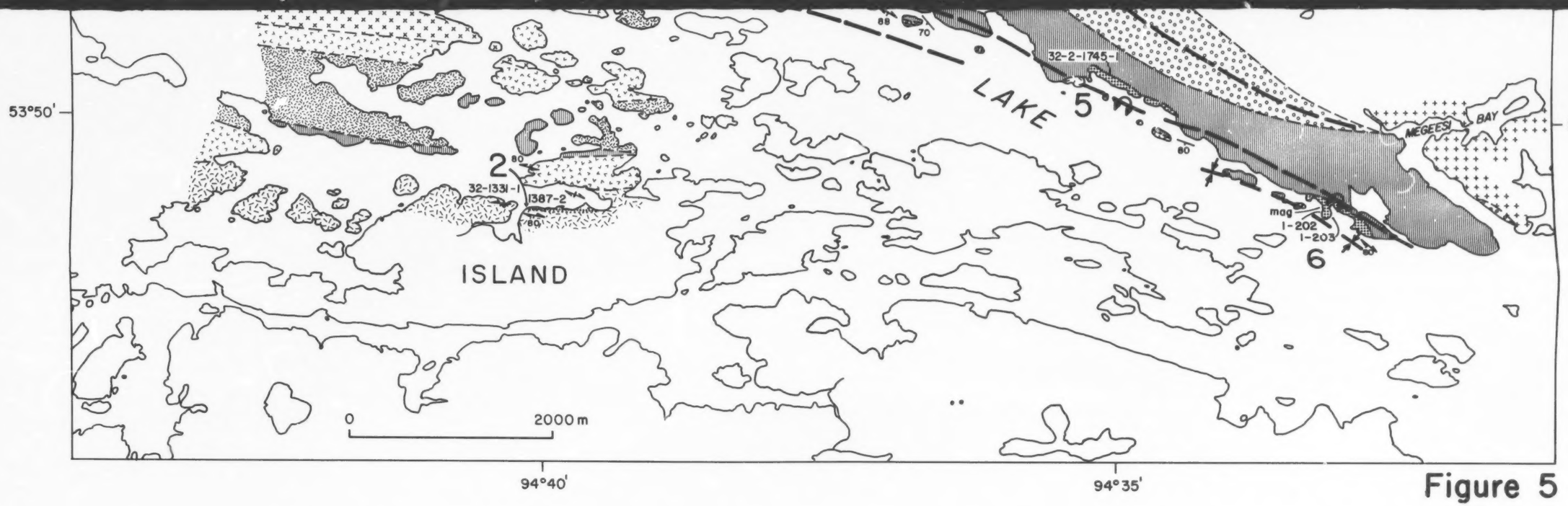
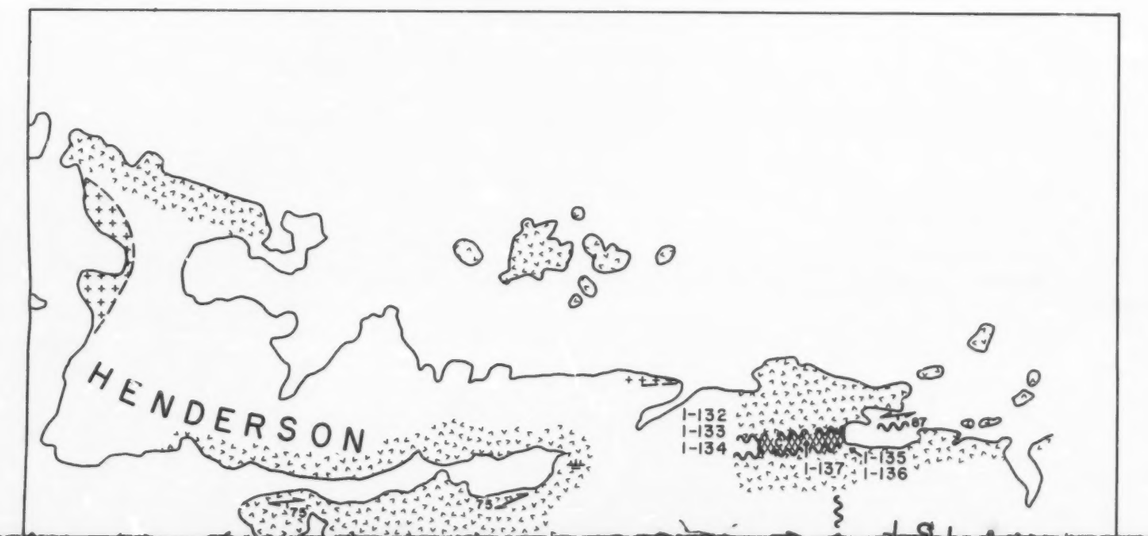
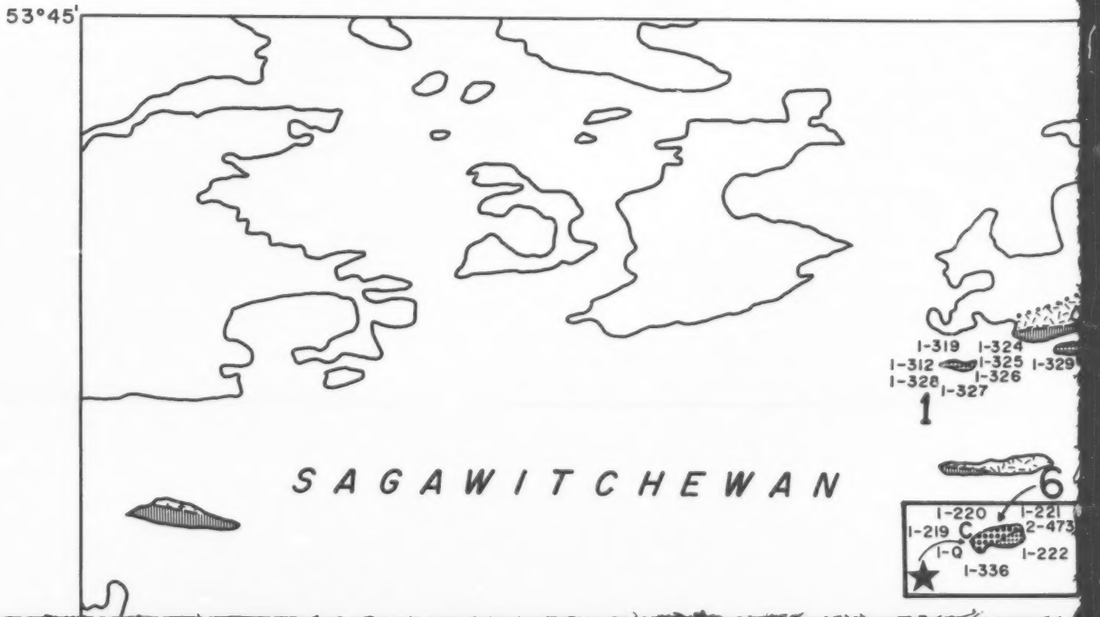

53°50'
LAKE 5
MEGEES BAY
32-2-1745-I
2
32-1331-I
1387-2
ISLAND
mag
I-202
I-203
6
0
2000 m
94°40'
94°35'

Figure 5


HENDERSON
I-132
I-133
I-134
I-135
I-136
I-137


53°45'
SAGAWITCHEWAN
I-319
I-324
I-312
I-325
I-329
I-328
I-326
I-327
1
6
I-220
I-221
I-219
2-473
I-Q
I-222
I-336

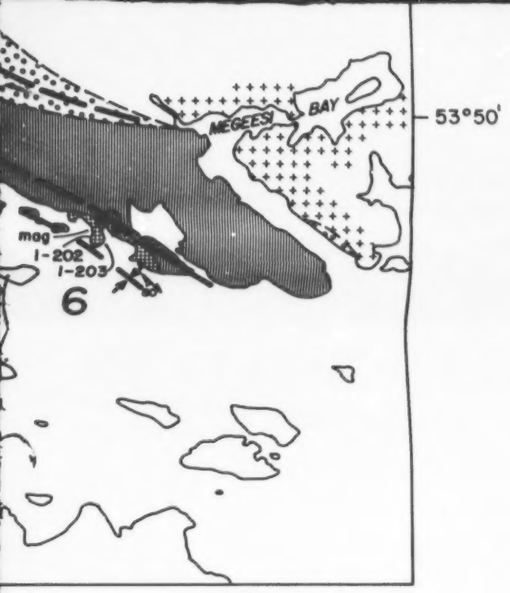



Figure 5

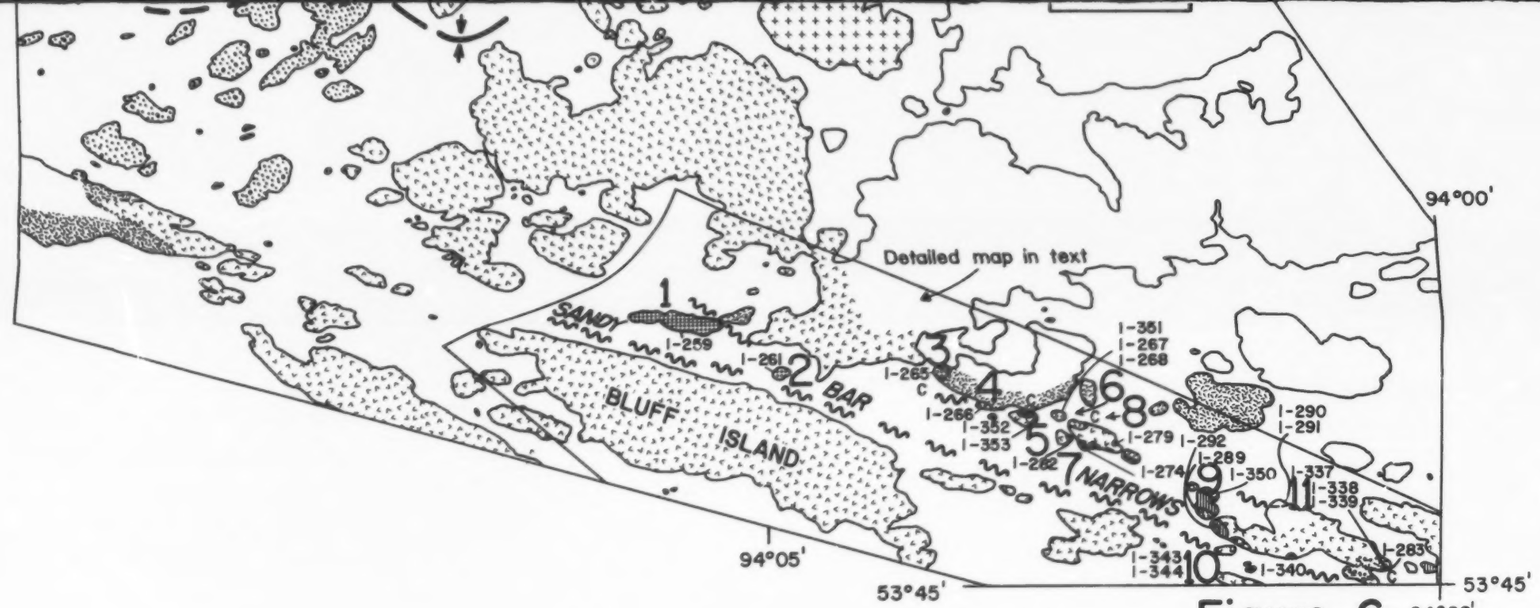
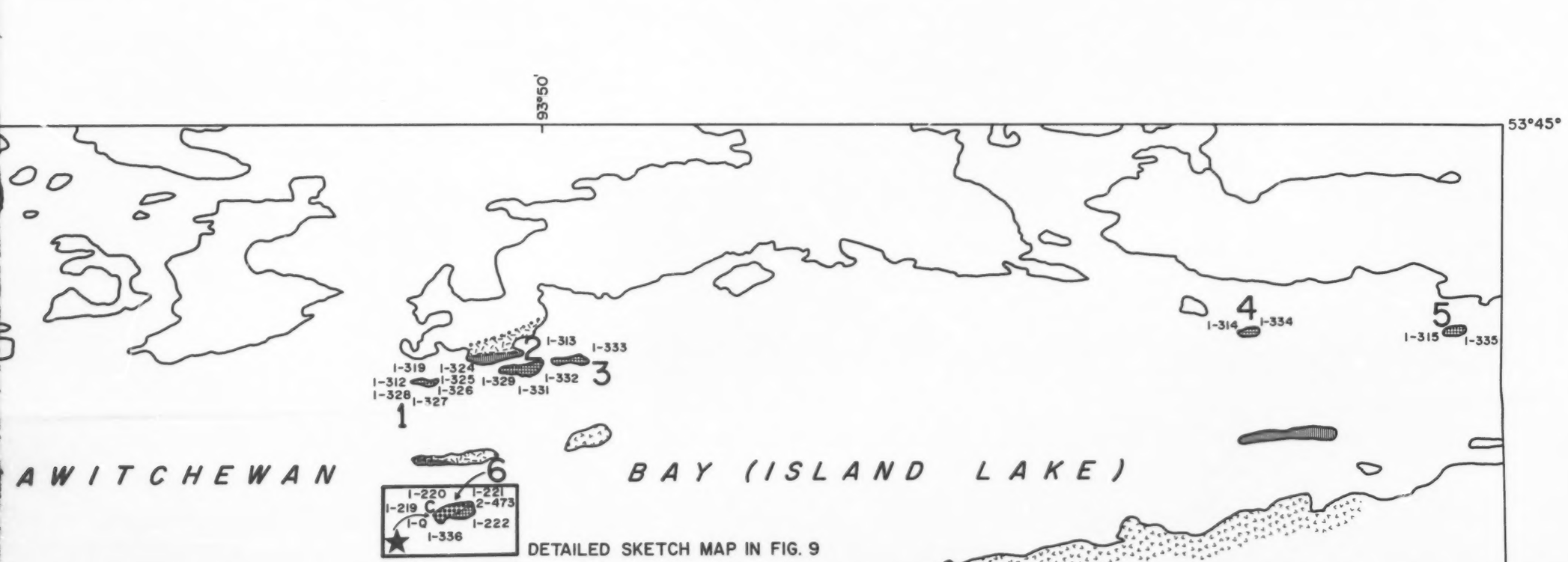



Figure 6




Mafic to interme

Geological con

Foliation (incl

Faults (approxi

Axial trace of

Axial trace of

Axial trace of

Axial trace of

Pillows (tops k

Pillows (tops u

Ultramafic rock

2 Ultramafic occu

I-238 Location and nu

c Carbonatization

bl Bleaching

asb Asbestos

il Ilmenite

mag Magnetite

hem Hematite

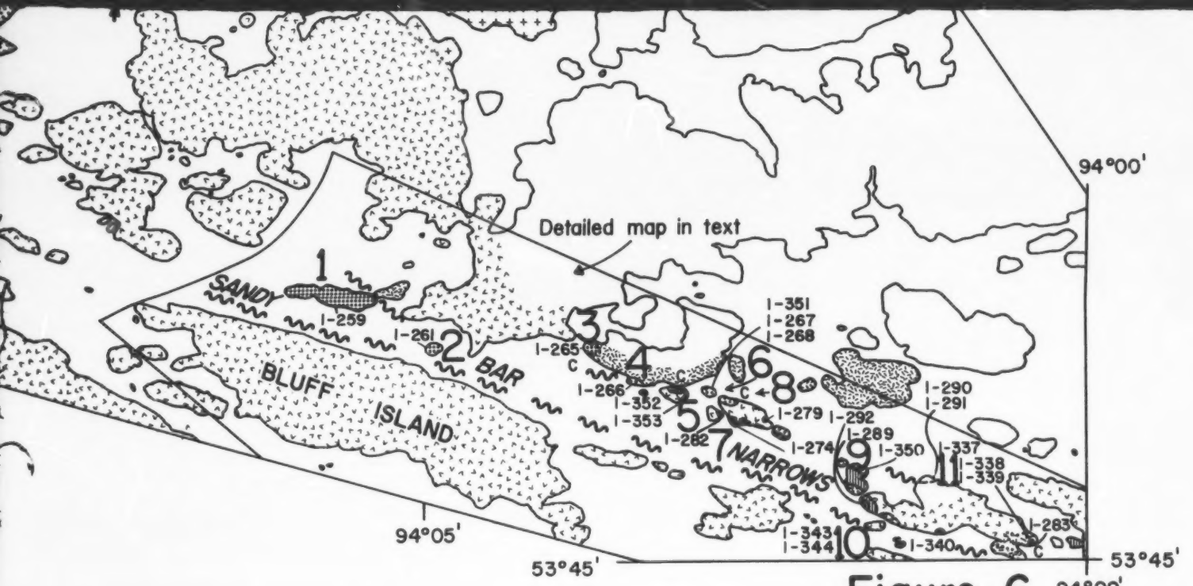
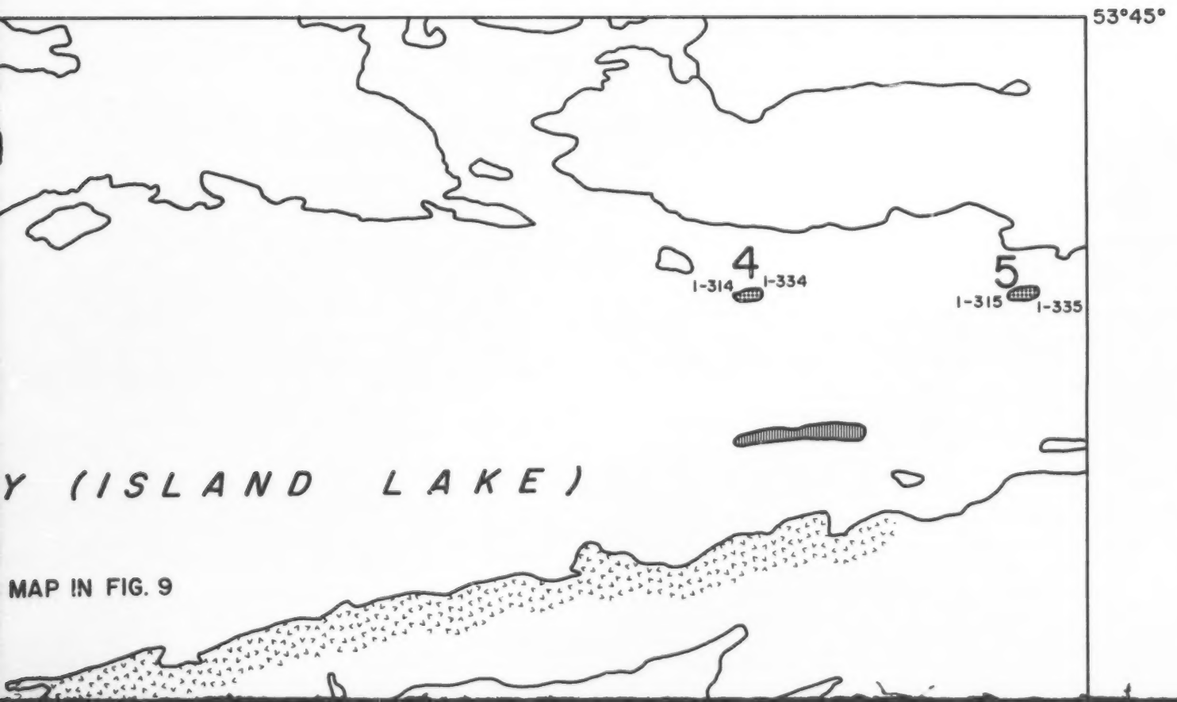



Figure 6




Mafic to intermediate volcanic and related intrusive rocks

## SYMBOLS

Geological contact (defined, approximate, assumed)

Foliation (inclined, vertical)

Faults (approximate location)

Axial trace of anticline (approximate location)

Axial trace of syncline (approximate location)

Axial trace of overturned syncline (approximate location)

Axial trace of overturned anticline (approximate location)

Pillows (tops known)

Pillows (tops unknown)

Ultramafic rocks (drill core information)

2 — Ultramafic occurrence number

I-238 — Location and number of rock sample

c — Carbonatization

bl — Bleaching

asb — Asbestos

il — Ilmenite

mag — Magnetite

hem — Hematite

ISLAND

0 2000 m

94°40'

94°35'

Figure 5

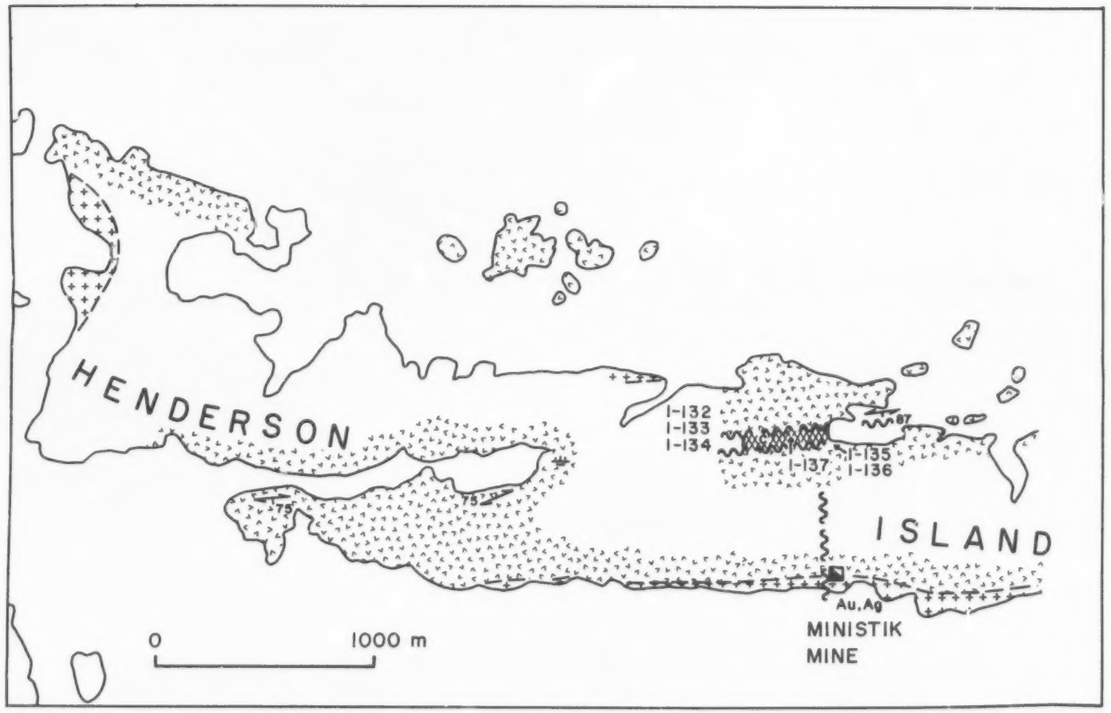
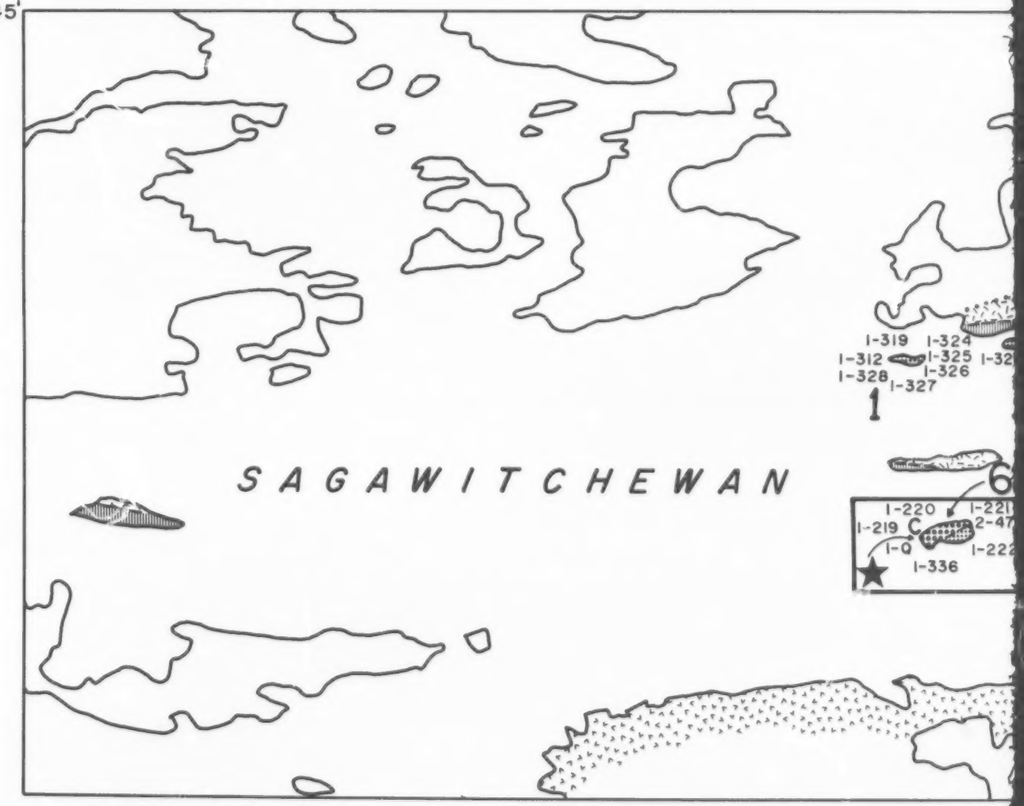



Figure 10



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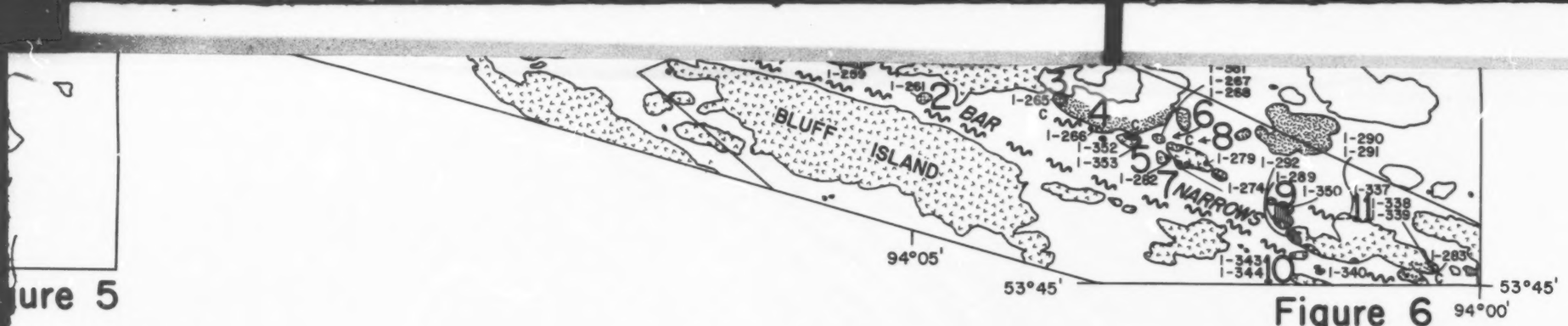


Figure 6

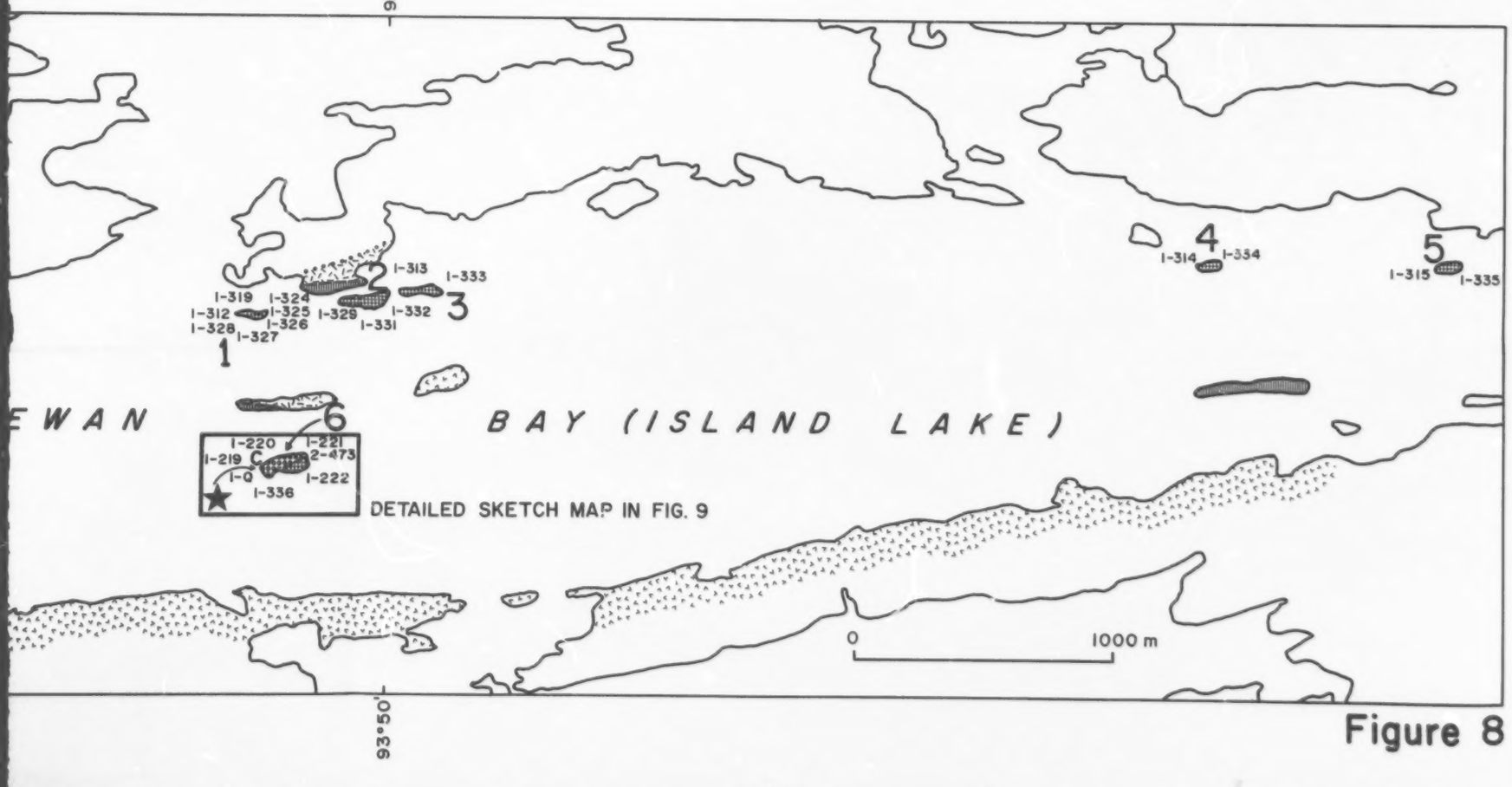


Figure 8

Geological contact (defined, approximate, ass

Foliation (inclined, vertical)

Faults (approximate location)

Axial trace of anticline (approximate locati

Axial trace of syncline (approximate location

Axial trace of overturned syncline (approxima

Axial trace of overturned anticline (approxi

Pillows (tops known)

Pillows (tops unknown)

Ultramafic rocks (drill core information)

2 Ultramafic occurrence number

I-238 Location and number of rock sample

c Carbonatization

bl Bleaching

asb Asbestos

il Ilmenite

mag Magnetite

hem Hematite

SAGAWITCHEWAN BAY Location and outline of detailed geolog location map.

Geology modified after Godard, 1963; Ames, 1975; Theyer, 1 1981; Weber et al., 1982.

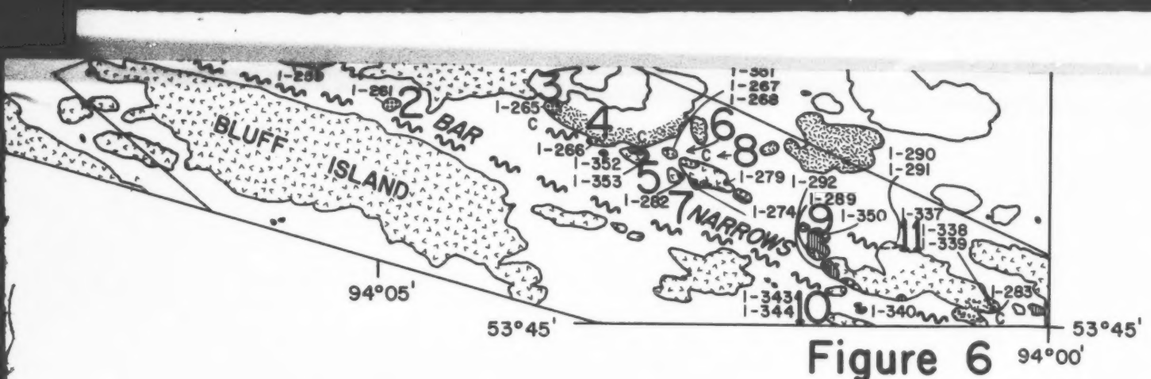


Figure 6

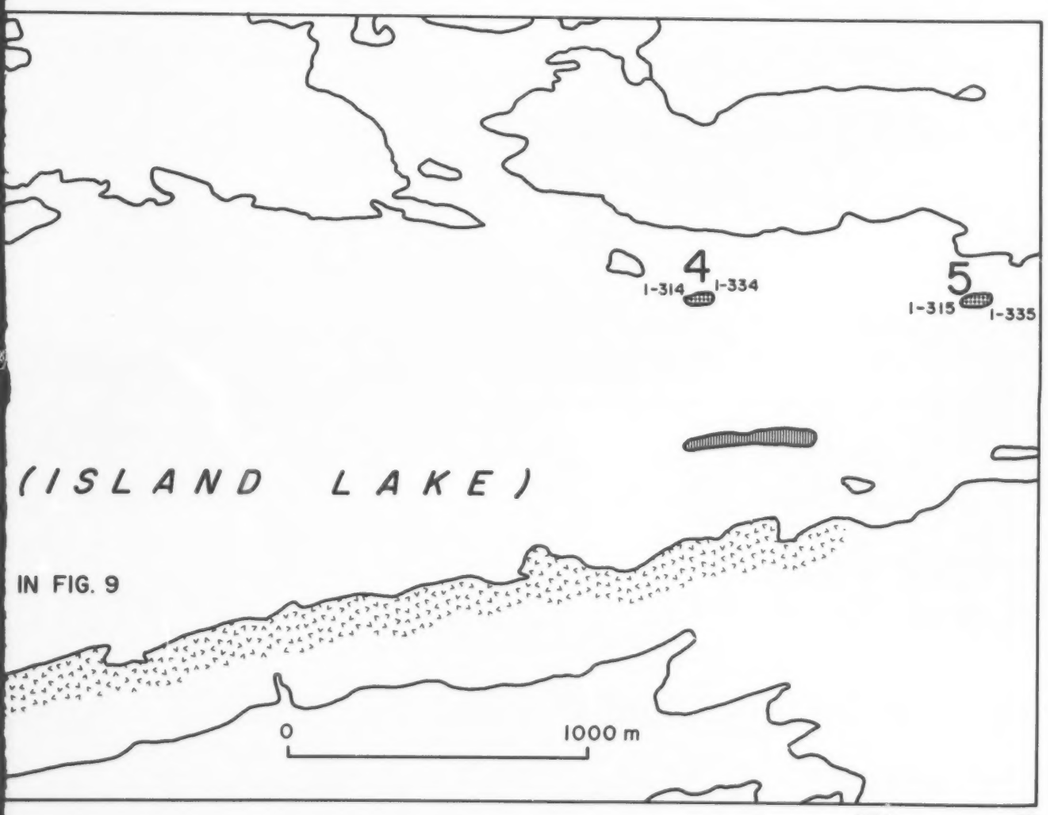


Figure 8

Geological contact (defined, approximate, assumed)

Foliation (inclined, vertical)

Faults (approximate location)

Axial trace of anticline (approximate location)

Axial trace of syncline (approximate location)

Axial trace of overturned syncline (approximate location)

Axial trace of overturned anticline (approximate location)

Pillows (tops known)

Pillows (tops unknown)

Ultramafic rocks (drill core information)

2 Ultramafic occurrence number

I-238 Location and number of rock sample

c Carbonatization

bl Bleaching

asb Asbestos

il Ilmenite

mag Magnetite

hem Hematite

SAGAWITCHEWAN BAY Location and outline of detailed geological and sample location map.

Geology modified after Godard, 1963; Ames, 1975; Theyer, 1980; Neale and Weber, 1981; Weber et al., 1982.